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1967

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The symbol on the cover is the one that has been used in the floor of the entrance to the K. W. Neatby Building, Central Experimental Farm, Ottawa. The center of the symbol is composed of an asymmetrical arrangement of the basic chemical elements of agricultural science as represented by Daltonian symbols. The colors represent the following atom models: black for carbon, light blue for oxygen, dark blue for nitrogen, and orange for hydrogen. The wreathlike ring with constantly changing proportions of light and dark green symbolizes growth.

research report
1967

Research Branch
CANADA DEPARTMENT OF AGRICULTURE

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ROGER DUHAMEL, F.R.S.C.
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1968

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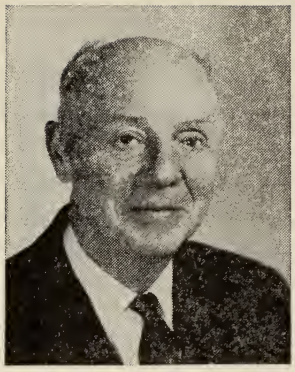

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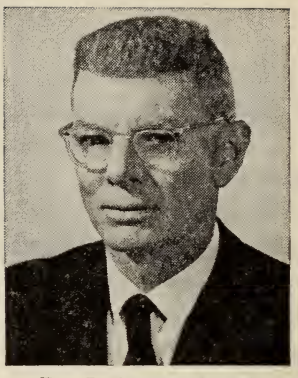

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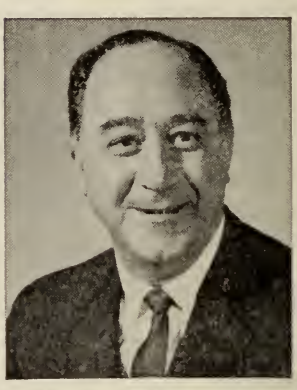
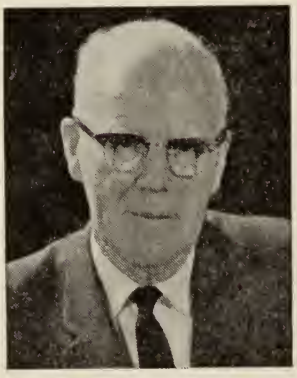
Dr. R. A. Ludwig



Dr. B. B. Migicovsky



Dr. K. Rasmussen

Dr. D. G. Hamilton

EXECUTIVE OF THE RESEARCH BRANCH

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Assistant Director General (Administration)

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Assistant Director General (Eastern)

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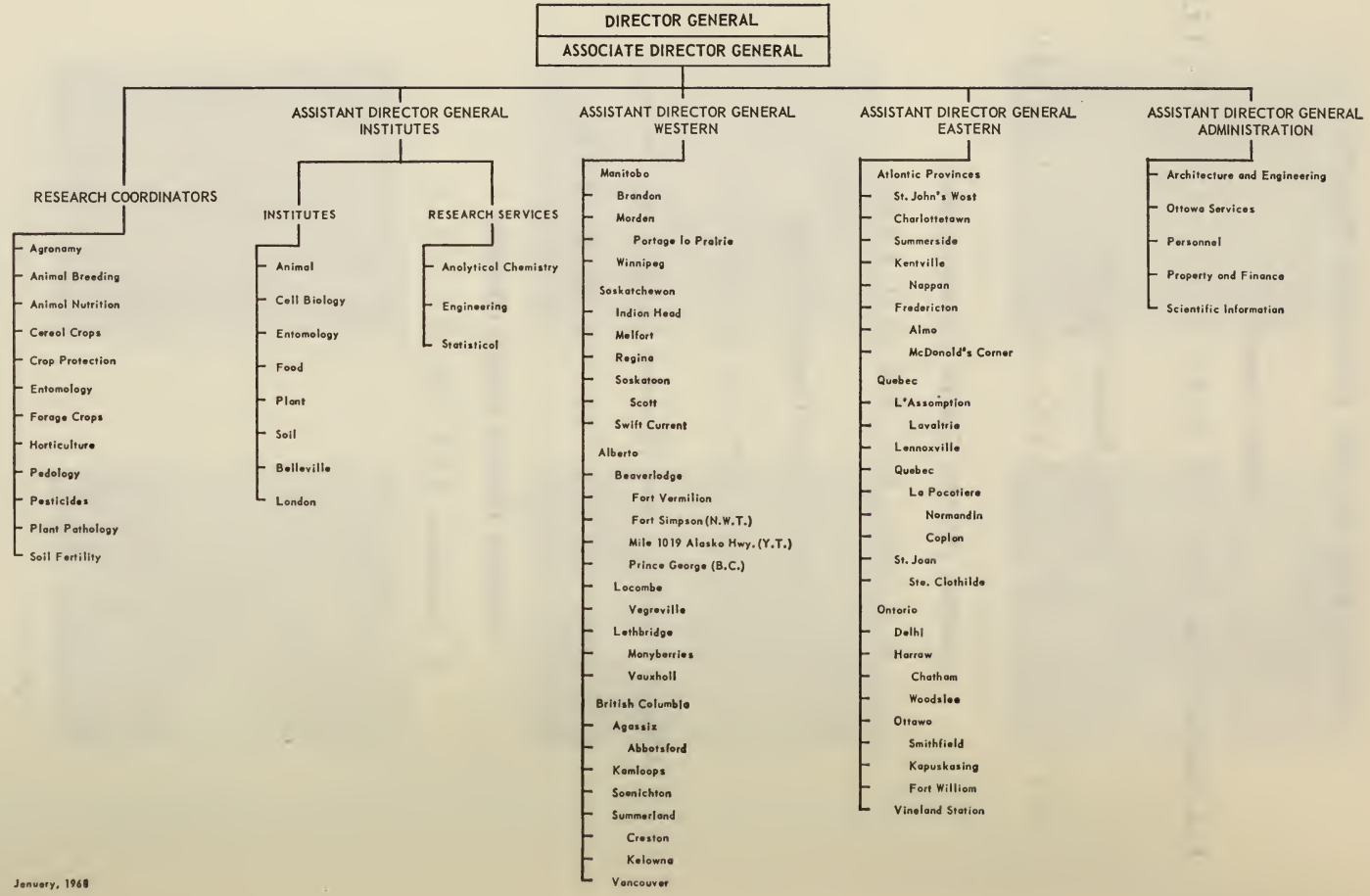
Assistant Director General (Research Institutes and Services)

B. B. Migicovsky, B.S.A., M.S., Ph.D., F.C.I.S., F.A.I.C.

Assistant Director General (Western)

K. Rasmussen, B.S.A., M.S., Ph.D., F.A.I.C.

CANADA DEPARTMENT OF AGRICULTURE
RESEARCH BRANCH



January, 1968

FOREWORD

The Research Branch of the Department of Agriculture is the largest research organization in Canada. The Branch conducts basic and applied research on soils, plants, animals, pests, diseases, engineering, and food, involving some 1,600 projects.

The Branch has its headquarters at the Central Experimental Farm, Ottawa. There are research establishments in every province and territory. Investigations are primarily discipline oriented in the research institutes and research services, located mainly at Ottawa, and problem oriented in the research stations and experimental farms throughout Canada.

There is close cooperation between the Branch and other federal agencies (particularly the Department of Forestry and Rural Development and the National Research Council), the agricultural industry, farm organizations, provincial research and extension organizations, universities, and international organizations.

This is the first annual report of the Branch and replaces the biennial and triennial research reports previously published by each establishment. There is a separate chapter in this report for each establishment and reprints are available from the establishments.

J. A. Anderson
Director General

BRANCH EXECUTIVE

The Executive is headed by the Director General, who is responsible for organization, operational procedures, overall development, and coordination. The Director General and the Associate Director General divide this work load, with the main emphasis of the Director General on policy and that of the Associate on operations.

Three of the Assistant Directors General are responsible for groups of establishments: one for the research institutes and services, one for the establishments in Western Canada, and one for those in Eastern Canada. The fourth is responsible for the administrative services throughout the Branch.

Largely as a result of the report of the Royal Commission on Government Organization, the procedure for developing cost estimates is being changed to include output as well as input. For some years the Branch has authorized and recorded research activities in terms of specific projects. During 1967 a coding system was introduced for grouping projects into program areas for estimates based on output. An inventory, in terms of professional man-years, was completed for all projects and thus all program areas; this work was undertaken in cooperation with the Canadian Agricultural Services Coordinating Committee. A procedure was started for accumulating annual costs for program areas based on this coding system. Flexible and detailed analysis has been achieved by using a computer-oriented system to store and process these records.

The reorganization that started 4 years ago has been almost completed. Professional staff in multidisciplinary teams has been concentrated at the large research stations with experimental farms serving as associated research establishments. A few small units, which have served their purpose, have been closed. The animal research has also been concentrated in fewer stations than previously.

During the year, the Branch gave top priority to developing the Engineering Research Service, the Statistical Research Service, and expanding the facilities for the Animal Research Institute on 2,600 acres in the Ottawa "Green Belt." Considerable progress was made in developing staff for research on pesticide problems.

Dr. D. G. Hamilton, Assistant Director General (Eastern), was granted a year's leave of absence, from July 1, to take part in the Government's Bicultural Program at Laval University. Dr. J. R. Wright, Director of the Research Station, Kentville, replaced him in an acting capacity. All members of the Executive have traveled widely in Canada to keep in close touch with the widespread research activities of the Branch.

RESEARCH COORDINATORS

J. C. Woodward, M.C. and Bar, B.S.A., M.S., Ph.D., F.C.I.C., F.A.I.C.	Associate Director General
H. J. Atkinson, B.A., M.Sc., Ph.D., F.C.I.C., F.A.I.C.	Soil Fertility
C. J. Bishop, B.Sc., M.A., Ph.D., F.R.S.C.	Horticulture
J. L. Bolton, B.Sc., M.Sc., Ph.D., F.A.I.C., F.A.A.A.S.	Forage Crops
W. A. Ehrlich, B.S.A., M.Sc., Ph.D.	Pedology
H. Hurtig, B.Sc., Ph.D.	Pesticides
A. S. Johnson, B.S.A., M.Sc., Ph.D.	Animal Breeding
E. J. LeRoux, B.A., M.Sc., Ph.D.	Entomology
J. W. Morrison, B.Sc., M.Sc., Ph.D.	Cereal Crops
F. S. Nowosad, B.S.A., M.Sc.	Agronomy
D. G. Peterson, B.A., M.Sc.	Crop Protection
W. J. Pigden, B.S.A., M.Sc., Ph.D.	Animal Nutrition
A. J. Skolko, B.Sc.F., M.A., Ph.D.	Plant Pathology

The Research Coordinators advise both the Executive and the Directors of Research Institutes, Services, and Stations on the development and coordination of research. They cooperate with Canadian and international organizations.

The Coordinators endeavor to visit all the establishments working on research in their disciplines at least once a year to consult with the directors and their staffs. In groups, they make special studies of selected program areas. They also advise on all new projects and review existing projects.

The Coordinators hold key positions on all national committees dealing with agricultural research. They organize and chair Work Planning Meetings at which research staff of the Branch, provincial organizations, and universities consider particular areas of the research program.

Dr. W. A. Ehrlich became Research Coordinator (Pedology) to replace Dr. A. Leahey, who retired in 1966. Dr. W. J. Pigden was appointed Research Coordinator (Animal Nutrition) to replace Dr. F. Whiting, who became Director of the Research Station, Fredericton, N.B.

ADMINISTRATION

R. A. Ludwig, B.Sc., M.Sc., Ph.D., F.A.P.S.	Assistant Director General (Administration)
J. P. McCrea	Chief of Property and Finance Section
G. N. Denike, B.S.A.	Chief of Architectural and Engineering Section
C. E. Chaplin, B.Sc., M.Sc., Ph.D.	Chief of Scientific Information Section
A. I. Magee, B.Sc. (Agr.), M.S.A.	Chief of Ottawa Services Section
D. Godfrey	Branch Personnel Adviser

The concept of responsibility center management has been introduced into the administrative procedures of the Branch. This involves changing existing systems to fit departmental and governmental procedures, and developing a more effective system of long-range program planning. A procedure has been developed for the classification of our activities on a professional man-year basis. Financial records are being coded to permit machine processing and the tabulation of meaningful cost statistics. A comprehensive program-planning and evaluation procedure is thus being developed in line with current government managerial philosophies.

Branch Administration has been heavily involved in the implementation of collective bargaining for the Public Service and with departmental and general changes in personnel administration.

Accommodation continues to be a major problem at many of our establishments, but steady progress has been made. A new laboratory with ancillary services has been completed at Vineland and a major rebuilding program is under way at Harrow. Barns, greenhouses, and service buildings have been completed or are under construction at a number of establishments. The largest of these projects has been the erection of animal housing for the Animal Research Institute in the new Greenbelt Farm in Ottawa.

RESEARCH INSTITUTES AND SERVICES

The Institutes are organized along specific lines of interest. Several disciplines are together in one Institute to solve problems in a specific area. For example, the Soil Research Institute uses chemistry, physics, mineralogy, and microbiology to solve problems of interest to agriculture.

The three Research Services, Analytical Chemistry, Engineering, and Statistical, carry out research in these areas in coordination with the program of the Branch. They also serve as sources of expertise in these areas. For example, the Analytical Chemistry Research Service analyzes materials as part of a research program of a research station. This service also conducts research on the development of new methods of analysis and the modification of methods for specific uses.

All basic and applied research that is conducted by the Institutes and Services is directed towards the solution of agricultural problems. However, the results may be applied outside of agriculture in fields such as fisheries, forestry, wildlife, and medicine.

Several organizational changes and expansions occurred in 1967. A group of scientists was transferred from the Entomology Laboratory, Chatham, to the Research Institute, London, which is now able to do research on the metabolism and fate of pesticides in the soil. The biochemists, plant pathologists, and virologists of the Plant Research Institute were joined with the Microbiology Research Institute to form the Cell Biology Research Institute.

Plans have been made to expand the Engineering Research Service to meet the growing demands for more effective research and development of engineering in the agricultural industry. Mr. Wm. Kalbfleisch, who organized the Service in 1959, served effectively as its Chief until his untimely death on June 18, 1967. Mr. C. G. E. Downing is now the Director of this service.

Dr. P. S. Corbet has been appointed as the Director of the Research Institute, Belleville, Ont.

B. B. Migicovsky
Assistant Director General
(Institutes)

WESTERN REGION

The western region, stretching from the Ontario boundary to the Pacific Ocean, and from the American border to permafrost in the north, is characterized by a semiarid, continental climate except for the western parts of British Columbia. In this region lie the main cereal-producing areas of Canada, extensive grassland areas for livestock production, and the last large frontier of virgin land that has agricultural potential. Within these broad complexes are special crop-production areas based on irrigation and the favorable coastal climate of British Columbia. The extremes and variability of climate, hazards of diseases and insects (some of them airborne from the United States), variability in soil types and fertility, and the impact of technology and economic changes on production combine to present a complex of problems requiring research for their solution. A continuing, coordinated research program is maintained by the staff of 15 research stations and six experimental farms located at strategic points.

K. Rasmussen
Assistant Director General
(Western)

EASTERN REGION

From Newfoundland to the western border of Ontario there are 11 research stations and seven experimental farms.

Progress continued during 1967 in a consolidation of research effort throughout the Atlantic Region. The plan whereby each establishment undertakes to lead in certain areas of research for the whole region was almost fully operative by the end of the year. For example, the Research Station, Charlottetown, P.E.I., gives leadership on research pertaining to the nutrition of forage plants. The new animal nutrition group began functioning at the Research Station, Fredericton, N.B., early in 1967. Mr. R. F. Morris is the Acting Director of the Research Station, St. John's West, Nfld., while Mr. H. W. R. Chancey is on loan to the Province of Newfoundland. Dr. L. P. S. Spangelo is the Acting Director of the Research Station, Kentville, N.S., during Dr. Wright's absence.

Research strength continued to grow in Quebec. A number of new appointments were made to the main establishments. Dr. J. C. Perrault is the Director of the new Research Station, Quebec, on the campus of Laval University. A nucleus of staff is being housed in the Faculty of Agriculture pending construction of Branch research facilities. Mr. J. M. Girard has been appointed Director of the Research Station, La Pocatière, Que.

The Entomology Laboratory at Chatham, Ont., underwent a major change during 1967. Part of the staff and program were transferred to the Research Station at Harrow and the remainder to the Research Institute at London.

In the eastern region, the planning of long-term research objectives and many immediate ones takes place through joint provincial and federal efforts. Cooperative efforts involving provincial and federal departments of agriculture and industry are working well.

D. G. Hamilton
Assistant Director General
(Eastern)

Animal Research Institute
Ottawa, Ontario

PROFESSIONAL STAFF

R. S. Gowe, B.S.A., M.S., Ph.D.	Director
G. T. Spurr, B.A.	Administrative Officer

Biochemistry Section

F. Sauer, D.V.M., M.S., Ph.D.	Chief of Section Short-chain fatty acids and ketone bodies
J. D. Cipera, M.S.A., Ph.D.	Structure and metabolism of connective tissue
D. S. Dow (Miss), B.A.	Energy metabolism
J. D. Erfle, B.S.A., M.S., Ph.D.	Intermediary metabolism
T. S. Foster, B.Sc., M.Sc., Ph.D.	Adrenal hormones and metabolism
K. J. Jenkins, B.S.A., M.Sc., Ph.D.	Selenium metabolism
B. B. Migicovsky, B.S.A., M.S., Ph.D., F.C.I.S., F.A.I.C.	Cholesterol metabolism
N. K. Sarkar, B.Sc., M.Sc., D.Sc.	Nucleic acids and proteins
F. A. Vandenheuvel, B.Sc., M.Sc., Ph.D.	Lipoproteins, biological membranes, and steroids

Genetics Section

F. K. Kristjansson, B.S.A., M.S., Ph.D.	Chief of Section Serum protein polymorphisms
R. S. Gowe, B.S.A., M.S., Ph.D.	Poultry breeding: egg stock
A. A. Grunder, B.S.A., M.Sc., Ph.D.	Serum protein polymorphisms
C. G. Hickman,[1] B.S.A., M.S., Ph.D.	Dairy cattle breeding
A. J. Lee, B.S.A., Ph.D.	Dairy cattle breeding
E. S. Merritt, B.S.A., M.Sc., Ph.D.	Poultry breeding; meat stock and geese
J. Nagai, B.A., D.A.	Mouse genetics
H. F. Peters, B.S.A., M.S., Ph.D.	Sheep genetics
E. Scheinberg, B.S., M.S., Ph.D.	Tribolium; quantitative genetics

[1] On transfer of work at Iowa State University, Ames, Iowa, October 1967 to October 1968.

Nutrition Section

D. P. Heaney, B.S., M.S., Ph.D.	Acting Chief of Section Forage utilization
J. R. Aitken, B.S.A., M.Sc., Ph.D.	Poultry nutrition: proteins
L. J. Fisher, B.S.A., M.Sc., Ph.D.	Dairy cattle nutrition
M. Hidiroglou, D.V.M., D.N.	Selenium and vitamin E
J. R. Hunt, B.S.A., Ph.D.	Poultry nutrition: egg quality
W. A. Jordan, B.S.A.	Beef cattle nutrition
J. R. Lessard, B.A., B.S.A., M.S., Ph.D.	Forage conservation
E. E. Lister, B.Sc. (Agr.), M.Sc., Ph.D.	Beef cattle nutrition

Physiology Section

H. A. Robertson,[2] B.Sc., Ph.D., F.R.I.C., F.R.S.E.	Chief of Section Reproductive physiology
K. G. Hollands, B.A., B.S.A., M.S.A.	Physiological genetics
W. G. Hunsaker,[3] B.S.A., M.S.A., Ph.D.	Cardiovascular physiology

Departures

G. E. Dickerson, B.Sc., M.S., Ph.D. Resigned October 1967	Quantitative genetics
G. L. Frederick, D.V.M., M.Sc. Transferred to Department of National Health and Welfare, Ottawa, December 1967	Vitamin B_{12} and iron
W. J. Pigden, B.S.A., M.S., Ph.D. Appointed Research Coordinator, Research Branch, Ottawa, June 1967	Chief of Nutrition Section
R. E. Smith, B.Sc., M.Sc., Ph.D. Resigned October 1967	Amino acid requirements of poultry

INTRODUCTION

In 1967 substantial progress was made on the construction of new animal and poultry research facilities at the Institute's new 2,800-acre premises in the "Greenbelt" of Ottawa. The site is now totally accessible from internal service roads and the water and sewer systems are completed. The electrical power and telephone distribution program is moving ahead as the buildings develop. Nine poultry buildings are now occupied. Two new dairy cattle barns to accommodate 500 calves, heifers, and dry cows and a maternity section for the planned 1,000 dairy cattle breeding research herd are nearing completion. One cow stanchion barn for 240 milking cows is in use. Three dairy barns for intensive research work on calves, heifers, and milking cows were started. The service complex of four buildings to house shops, weighbridge, machinery, and vehicles was also started. The completion of these buildings will permit a start in the consolidation and intensification of the genetics and nutrition programs for dairy cattle and poultry.

[2] Appointed August 1, 1967.
[3] On transfer of work at Baylor University, Houston, Texas, September 1967 to September 1968.

In the design of the new animal and poultry housing, extensive use has been made of liquid-manure handling systems, automatic feeding for roughages and concentrates, and controlled ventilation and lighting without windows in the animal areas. These new facilities will permit more carefully controlled year-round large-scale experimental work with domestic species.

The Physiology Section was organized during the year. The major emphasis at the start will be placed on the development of a fundamental research program in reproductive physiology.

Considerable progress has been made this year in understanding the basic cause of White Muscle Disease in cattle and in preventing its occurrence. New techniques developed for the separation and identification of steroids have been well received and are being widely used to study the role of steroids in healthy and diseased conditions. Results from studies on the nutrition of the young bovine, beef cow and the milking cow are pointing the way to the development of more efficient beef and milk production. Studies on the very early weaning of lambs indicates this procedure may have several practical advantages.

R. S. Gowe
Director

BIOCHEMISTRY

Adrenal Steroids

Separation, identification, and quantitative estimation of steroids—Further refinements in procedures for separation, indentification, and quantitative estimation of low levels of steroids were established. The advantage of using pilot dyes in the precise location of steroid bands in thin-layer chromatograms (TLC) was established and methods for the complete recovery of very small amounts of steroids from TLC plates were devised. Structure-related effects of temperature and of quantity injected in gas–liquid chromatography (GLC) of steroids were studied systematically and simple methods were established for the identification of these compounds. A systematic kinetic study of the reduction of carbonyl groups in 48 steroids was completed. Reduction products were identified, and their structure and relative abundance were determined. Reliable methods were developed for the identification and quantitation of corticosteroids by TLC and GLC. This procedure was used for the analysis of cerebrospinal fluid and the detection of human malignant brain tumor. No false-positive result was observed in nearly 200 cases.

Mechanism of adrenal steroid action—Triamcinolone, a highly potent synthetic steroid when administered to starved adrenalectomized rats, restored blood glucose and liver enzymes to normal levels. The action of triamcinolone can be blocked by actinomycin D. Casein hydrolysate stimulated the gluconeogenic effect of triamcinolone only in intact but not in adrenalectomized rats. The apparent reason is that adrenalectomy greatly reduced the activities of oxalectic and glutamic-pyruvic transaminases. The administration of triamcinolone resulted in a threefold increase in the activities of these enzymes.

Connective Tissue Metabolism in Developing Bone

Calcium and connective tissue interrelationship in rachitic chicks—Nineteen amino acids and two amino sugars were identified in chick cartilage. When the calcification process in the epiphyseal cartilage was slowed down by rickets, the levels of typical mucopolysaccharide (MPS) constituents, hexosamines (mainly galactosamine) were significantly depressed, whereas those of typical collagen constituents, hydroxyproline and hydroxylysine, were increased. These changes were reversed in vitamin D. Parathyroidectomy of chicks increased the levels of hydroxyproline, glycine, leucine, phenylalanine, and arginine. Administration of Para-thormone (PH) reversed these changes. Lysine concentration was decreased very significantly by the administration of PH.

Regulation of connective tissue enzymes in rats—The levels of activity of enzymes in glucuronic acid metabolism were significantly increased in sham-operated rats that were treated with corticosterone, cortisone, or hydrocortisone. Enzyme activities were restored to normal levels by the injection of corticosterone, cortisone, or hydrocortisone in adrenalectomized animals. Deoxycorticosterone, progesterone, or Reichstein's substance S usually resulted in little or no change in activity of the enzymes.

Energy Utilization

Electron transport and energy coupling in mitochondria—Tightly coupled skeletal muscle mitochondria underwent rapid active swelling when suspended in the absence of Mg^{++} or in the presence of thyroxine, or in the presence of valinomycin. This active swelling was adenosine triphosphate dependent, but it was not supported by uncoupled substrate oxidation. The active swelling that resulted from the omission of Mg^{++} from the medium was Na^{+}-activated. The swelling agents valinomycin and thyroxine act by inducing a K^{+} specificity for swelling. All three kinds of swelling show a permeant anion dependency. Both thyroxine and the absence of exogenous Mg^{++} appear to promote active physiological swelling by promoting facilitated diffusion. The addition of Mg^{++} causes contraction of mitochondria actively swollen in the absence of Mg^{++}. The removal of thyroxine by excess albumin causes contraction of mitochondria swollen in the presence of thyroxine. Albumin caused reversal of thyroxine swelling but not of swelling in the absence of Mg^{++}.

Metabolism of Ruminant Ketosis

Fatty acid oxidations—The ketotic syndrome was related to a decreased rate of tricarboxylic acid (TCA) cycle turnover. Contrary to the hypothesis of Krebs, ketogenesis cannot be ascribed solely to a decrease in oxalacetate concentration. The concentration of TCA cycle acids was greatly decreased by injecting ethionine intraperitoneally. This lowered the concentration of adenylates, particularly adenosine triphosphate (ATP), which was required in the synthesis of oxalacetate from pyruvate. When ethionine was given to ketotic guinea pigs the concentration of glucose and acetoacetate in blood decreased, clearly proving that ketosis is not simply the resultant of lowered carbohydrate stores in the animal. Turnover time of TCA cycle acids was unchanged in ethionine-treated guinea pigs in spite of the fact that the concentration of these acids decreased greatly. However, TCA cycle acids were present in normal concentrations in ketotic guinea pigs, and showed increased turnover times. This was the result of increasing concentrations of reducing equivalents produced by the β-oxidation of long-chain fatty acids, which caused a decreased oxidation-reduction potential in liver cells. The underlying defect in ketosis may be in the failure of tissue protein to furnish an adequate supply of glucogenic amino acids for the maintenance of the correct fatty acid to carbohydrate balance.

Enzyme changes in ketosis—One of the key enzymes involved in TCA cycle oxidations, α-ketoglutarate dehydrogenase, was investigated in order to study possible inhibition. This enzyme was irreversibly inhibited by long-chain acyl-CoA esters (C_{10}–C_{22}) with an inhibition constant for palmitoyl-CoA of 10^{-6} M. This inhibition could be prevented, but not reversed by albumin. The increased fatty acid concentration found in the liver of ketotic animals may therefore be responsible for the inhibition of this enzyme.

Nutritional Muscular Dystrophy (NMD)

Biochemical properties of selenium—Selenite ($SeO_3^{=}$) administered orally or intravenously using ^{75}Se to chicks as $^{75}SeO_3^{=}$ was rapidly bound by the tissue and body fluid proteins. Radioisotope studies demonstrated selenium was very tightly bound to serum protein and could only be released by prolonged incubation in alkaline buffer. Because the disulfide bonds of proteins are relatively unstable in alkaline solutions, this indicated that Se may be bound to the inter or intra S–S peptide linkages. Reduction of the S–S bonds with 0.5 M β-mercaptoethanol caused an immediate release of more than 90% of the activity. In concentrated urea solution wherein protein S–S bonds are known to rupture and rearrange, 95% of the Se activity was released.

Blood and liver selenium levels were low in the calves born from cows fed oat silage, but hepatic tocopherol was higher than in those born from cows fed NMD-producing hay.

Metabolism of inorganic selenium by rumen bacteria—Rumen bacteria were capable of metabolizing inorganic ^{75}Se and incorporating the element into microbial proteins. Characterization of the ^{75}Se-containing compounds in the rumen bacteria protein hydrolysates showed the presence of ^{75}Se seleno-methionine and ^{75}Se seleno-methionine selenoxide.

Prevention of nutritional muscular dystrophy—Winter feeding of oat silage to beef cows prevented the occurrence of nutritional muscular dystrophy (NMD) in calves.

Further results obtained from field experiments indicated that the development of myopathy in spring beef calves after their release to pasture was unrelated to an increase in physical activity or alteration in dietary or climatic conditions, but rather to the age of the animals and extent of Se depletion. Electrocardiography was found to be a useful tool for diagnosis of the cardiac form of the myopathy.

Cholesterol Metabolism

Glycerol as an inhibitor of cholesterol synthesis—In attempts to isolate the active inhibitory principle in a liver mitrochondrial extract, it was observed that glycerol was capable of inhibiting cholesterol synthesis, both in vitro and in vivo. Glycerol behaved like the mitochondrial extract in that it affected the synthesis prior to mevalonic acid in the synthetic sequence. A number of compounds similar to glycerol in structure were not active. The mode of action of glycerol in this reaction is under investigation.

GENETICS

Biochemical Polymorphisms

Hemopexins in rabbits and swine—A study of a genetically controlled heme-binding protein of rabbits showed that this protein is soluble in perchloric acid and binds heme and not hemoglobin. The protein was renamed hemopexin. An extension of this study has outlined a method for distinguishing heme-binding from hemoglobin-binding proteins in swine and rabbits.

Sex-associated serum esterases in domestic fowl—Electrophoretic variants of serum aliesterases, as observed on starch gels, were shown to be controlled by two codominant alleles in three meat lines of chickens. The staining intensity of these esterase zones was sex-associated among adults in that staining intensity was on the average greater in males than in females.

Fitness of mice classified for transferrin genotypes—There was no significant difference in litter size at birth among nine transferrin mating classes in a random-bred population. Segregation of the transferrin alleles was essentially normal. Since the genes controlling transferrin appeared fairly neutral in their effect on characters related to fitness, it is suggested that they may be used as genetic markers in experimental populations.

Dairy Cattle

Analysis of Record of Performance records—Previous work demonstrated that the regression of first lactation milk yield on age at freshening differs for different seasons. A recent study has shown that these regressions for different seasons are more alike when the herd-year-season average production is included as an independent variable in the regression equation. A system of adjusting first lactation yield records for age at freshening and level of herd production was developed. When second, third, and fourth and later lactation records were considered separately, the regression of yield on age was found to differ substantially for different lactation groups. Age at freshening between 5 and 10 years of age did not have an important effect for purposes of adjusting yield. The regression of the difference between first lactation and subsequent lactations on herd average differed for dif-

ferent lactations. A new method was developed that adjusts yield for herd level of production, age at freshening, and lactation number simultaneously. These hypotheses are being applied and evaluated on a set of data independent of those from which the procedures were derived.

Sheep

Performance in sheep weaned at 2 days and 70 days of age—Reciprocal crosses of Shropshire and Suffolk sheep were begun to evaluate heterosis in performance on two management regimes: weaning of lambs at 2 days of age and weaning at 70 days. Nippled-feeders were used to dispense milk replacer to the lambs weaned at 2 days and the remainder of the lambs nursed their dams to 70 days of age.

It was difficult to assess heterotic effects or breed differences with data for only 1 year. However, performance levels under various treatments were of interest. Within breeds, the lambs weaned at 2 days were 0.9 kg lighter than their contemporaries at 35 days of age, but were 4.4 kg heavier at 70 days. Single-born lambs were 3.6 kg heavier than twins at 70 days of age in the nursing lot, but there was no difference in 70-day weight between singles and twins weaned at 2 days of age. Mortality was higher in the 2-day lot owing to prevalence of bloat, but 80% of all lambs born survived to 70 days.

Pilot Organisms—Tribolium

Genotype–environment interaction in the red flour beetle, and its control by selection—Although genotype × environment interactions have been generally recognized, no experimental evidence has been presented concerning the effect of selection on the magnitude of such interactions. To test the feasibility of controlling genotype × environment interactions, an experiment was designed using pupal weight performance in two humidities. Selection was effective for the difference in performance on these two environments in the high and low directions as well as when selecting for no change in this difference. This implies that genotype × environment interaction for pupal weight performance can be controlled by selection. The results of this study are in agreement with the theoretical expectations.

Indirect selection for high larval weight in Tribolium castaneum (*Herbst*)—Under certain conditions it is theoretically possible that maximum genetic gain in a given trait can be achieved in a more efficient manner by selecting for another highly correlated trait. An experiment was designed to determine the rate of expected and realized genetic gain for high larval weight, when selecting directly for it (direct selection) and when selecting for pupal weight and observing larval weight (indirect selection). The criterion used to evaluate the relative efficiency of indirect selection was the ratio of gain due to indirect selection : the gain due to direct selection. The results of this experiment indicate that larval weight can be selected for indirectly by selection for pupal weight at least as effectively as when selected for directly.

Meat Production Poultry

Stabilizing selection in a control strain of meat-type fowl—The phenotypic variance estimate of 63-day body weight for randomly selected breeding males was about one-third less than the estimate derived from the total population from which they were selected. This finding was consistent over five generations. The reduction in variance could not be accounted for by sample size alone. Analyses indicated fewer parents than expected in both extreme weight classes.

Egg size and growth—Because the size of the chick and its subsequent growth has been shown to be related to the size of the egg from which it hatches, commercial standards have been set for a minimum size for eggs that are to be hatched. A comparison of the size of hatching eggs and subsequent growth of chicks was made on flocks of the same breed that differed in age. Although, as expected, they differed markedly in hatching-egg size, they did not differ in growth rate of chicks hatched. This suggests that the observed correlation between hatching-egg size and growth of chicks may be due to the larger eggs coming from larger hens and a positive genetic correlation between body size of parents and growth of progeny. This evidence suggests changes in current methods of applying size standards to hatching eggs.

Body-weight ratios as selection criteria in meat-type poultry—Genetic analyses have shown heritability estimates of 22 to 33% for the ratio of body weight at early ages to body weight at mature ages as contrasted with 38 to 59% for absolute weights. These ratio estimates are of sufficient magnitude for relatively efficient mass selection and may have advantages in an applied breeding program because of their favorable (positive) genetic correlations with early body weight and egg numbers.

Heterosis in domestic geese—Crosses from three breeds of domestic geese were superior in growth and reproductive performance to the purebreds from which they were derived. Unlike studies with both meat- and egg-type chickens, the crosses never exceeded the level of the superior parent in egg production, but improvement in both fertility and hatchability resulted in a greater number of goslings per breeding female.

Breeds and Breeding Methods

Methods of evaluating and utilizing breeds of livestock—The problem of evaluating breeds within countries and assessing the potential of exotic breeds was considered. Experimental designs were suggested, which would enable comparison of exotic breeds with local breeds, through introduction of males only, or through introduction of both males and females. These designs enable estimation of genetic gains to be expected from: grading up to an exotic breed, new breed development, and systematic crossbreeding. The minimum number of animals required for such tests were estimated.

NUTRITION

Poultry Nutrition

Protein requirements in broiler diets—Studies were conducted to determine the possibility of improving the amino acid pattern of practical broiler diets by amino acid supplementation, and of lowering the amount of protein required. When common grains and protein supplements were used, 22% protein was required to achieve maximum growth. When the protein of a corn–soybean meal ration was lowered to 16%, growth was reduced to 85% of maximum. This could be restored to 95% of maximum by supplementation with a combination of methionine, lysine, and glycine. Little or no response was obtained when these amino acids were added individually. There was no response to the further addition of threonine, tryptophan, and tyrosine.

Alleviation of amino acid toxicities by arginine—Excess quantities of several L-isomer amino acids added singly to a balanced low-protein casein diet caused growth reduction and reduced feed intake when fed to chicks. With the exceptions of those caused by tryptophan and leucine, the manifestations of imbalance were alleviated by the addition of 0.3 to 2.0% arginine to the diet.

Laying rations based on wheat, oats, and fish meal—Rations comprised principally of wheat required 5% fish meal to maximize laying performance. As much as 22% fish meal could be included without detriment to egg production. A mixture of wheat and oats (50:50) was superior to wheat alone when fed without a protein supplement and the supplemental fish meal required to maximize egg production was decreased from 5 to 2%.

Studies on egg shell quality—Impact studies have shown that the initial shell fracture occurs at a force lower than the maximum shell resistance. Correlation between initial and maximum force was 0.02. Shape of the impacting surface influenced initial and maximum force and was directly proportional to the surface area in contact with the shell.

Stress distribution studies indicated that the axes of stress can be predicted. Shell thickness, curvature, and ultimate tensile strength are important strength components. Initial failure occurs at the inner shell surface under tensile stress.

Magnesium distribution in the shell varied along the major axis with Mg:Ca lowest at the large pole. Samples from the outer to the inner surface of the shell indicated that Mg:Ca was highest at the inner, lowest at the middle, and slightly higher at the outer surface.

Nutrition of Lactating Cows

Sorghum – Sudan grass and corn silage in dairy rations—The dry-matter intake of sorghum – Sudan grass silage was comparable to that of corn silage, but milk production was higher from cows fed corn silage. The apparent dry-matter digestibility (by sheep) was 72.8% for the corn silage and 63.4% for the sorghum – Sudan grass silage.

Effect of infused acetic acid on milk fat content—Concentrate fed *ad libitum* with roughage restricted to 1.8 kg/day resulted in a 16% increase in milk production, a 30% decrease in milk fat, and a change in the ratio of acetic acid to propionic acid in the rumen fluid of 2.9:1.0 to 1.0:1.0. Acetic acid, intravenously infused, increased the percentage of fat from 2.27 to 2.89 and the daily yield of fat from 0.45 to 0.54 kg with no change in milk production.

Corn- or oat-based concentrates with high- or low-quality hay—Both digestibility and consumption of corn-based concentrate rations were higher than oat-based rations. Low-quality hay reduced the intake of concentrate slightly and decreased total ration digestibility. Solids-corrected milk production was greater for the corn-based concentrate, but the efficiency of production was better for the oat-based concentrate.

Intravenous infusion of methionine and lysine—Infusion of methionine with or without lysine had no effect on feed intake, milk production, or percentage of milk protein. Methionine alone increased free methionine and cystine levels in the blood serum. Infusions of methionine and lysine did not change serum lysine levels, but they slightly decreased all other amino acids. Blood ammonia levels decreased during amino acid infusions.

Meat Production from Holstein-Friesian Steers

Effect of early plane of nutrition—High-level feeding of a high-fat milk replacer for the first 8 weeks markedly increased the rate of gain compared with animals weaned from a similar milk replacer at 4 weeks onto an all-concentrate ration. Subsequent rate of gain on common rations was not different between the two groups, resulting in the high-plane animals reaching market weight 2 weeks earlier.

Slaughter weight—Rates of gain were similar for groups of steers fed all-concentrate diets to various slaughter weights (340, 386, 431, and 477 kg liveweight), but feed efficiency decreased with increasing slaughter weight. The area of the *longissimus dorsi* did not increase with increased carcass weight. There was a trend toward increased dorsal-fat thickness and an increased proportion of undesirable wholesale cuts with increasing slaughter weight.

Mortality in purchased Holstein-Friesian calves—Locally purchased calves, untreated or intravenously infused with either 250 or 500 ml of mature bovine plasma, had a mortality rate of 50% due to bronchial pneumonia, whereas those given routine antibiotic therapy all survived. A rapid screening test for total globulins indicated no relationship between this measurement and survival.

Beef Cow Nutrition and Management

Effects of winter housing and planes of nutrition—Beef cows wintered out-of-doors with only a windbreak and at ambient temperatures as low as −44C were compared with cows wintered indoors at the Experimental Farm, Kapuskasing, Ont. Birth weights were higher for the calves of cows wintered out-of-doors, but there was no difference in the rate of gain of calves from the two groups. Cows wintered out-of-doors had a slightly higher feed intake, but lost more body weight during the winter months. Intakes of grass silage (dry matter) were lower than those for the hay-fed groups. The cows fed grass silage lost body weight and reared slower-growing calves.

Forage Utilization

Evaluation of forage mixtures—Dry-matter digestibilities (DMD), dry-matter intakes (DMI), and digestible dry-matter intakes (DDMI) were determined with sheep for pure timothy and pure alfalfa hays, each cut at three stages of maturity. Known grass–legume mixtures of these pure species were then fed to the same sheep to compare observed DMD and DMI with those predicted from the components. There was good agreement between observed and predicted DMD. Observed DMI were more variable with observed values tending to be lower than predicted. When the feeds were ranked according to decreasing DMD, DMI, and DDMI values, there was good agreement within each forage species. However, for comparisons of the forage mixtures, there were marked differences among DMD, DMI, and DDMI, which demonstrates that neither DMD nor DMI alone is as useful as DDMI for estimating feed value.

Selenium content of forage crops at Kapuskasing, Ont.—Selenium content increased with advancing maturity in timothy and decreased in birdsfoot trefoil. In orchard grass, an initial increase was followed by a decrease. There was no seasonal change in the selenium content of reed canarygrass, creeping red fescue, or bromegrass. All these species contained less than the required amount of selenium for the protection of beef calves against nutritional muscular dystrophy.

PHYSIOLOGY

Cardiac Physiology

Round heart disease in turkey poults—Four commercial strains of turkeys were examined for round heart disease at 3 weeks of age by electrocardiagraphic analysis and postmortem examinations. The incidence was found to be 3, 18, 12, and 28%. In each strain almost twice as many males as females were affected. Mortality attributable to the disease was 8% in the strain with the highest incidence and 2% or less in the other three strains. Mean body weights were lower (7%) and heart weight to body weight ratios higher (0.78% compared with 0.49%) in affected than in normal poults.

Physiological Genetics

Serum cholesterol in fowl—Preliminary samples of two populations of White Leghorns (single comb) showed a difference in serum cholesterol levels between males and females. The males were slightly but consistently lower than the females at a sexually immature age (10 weeks). At sexual maturity (54 weeks) the values in the male showed no change, but the female level rose dramatically and variably to a level two to four times that of the immature level.

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Ottawa, Ontario

PROFESSIONAL STAFF

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W. C. Moore, B.Sc.	Administrative Officer

Biochemistry Section

R. M. Hochster, B.Sc., Ph.D.	Head of Section Microbial metabolism and enzymology
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J. M. Ingram, B.Sc., M.Sc., Ph.D.	Fungal metabolism and enzymology
S. M. Lesley, B.Sc., M.A., Ph.D.	Macromolecules and tissue culture
C. Madhosingh, B.S.A., M.A., Ph.D.	Biochemical taxonomy
J. G. Shaw, B.S.A., Ph.D.	Viral biochemistry
C. S. Stachow, B.Sc., M.Sc., Ph.D.	Enzyme regulation

Cryobiology Section

D. Siminovitch, B.Sc., M.Sc., Ph.D., Ph.D.	Head of Section Frost hardiness

Cytology Section and Electron Microscope Center

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Microbial Ecology Section

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E. A. Peterson, B.Sc., M.Sc., Ph.D.	Rhizosphere fungi
G. W. Skyring, B.Sc., Ph.D.	Microbial selection and numerical taxonomy

Physiology Section

R. B. Pringle, B.Sc., M.Sc., Ph.D.	Head of Section Pathogen-produced disease determinants
E. F. Schneider, B.Sc., M.Sc., Ph.D.	Physiology of growth control
J. C. Sirois, B.A., B.Sc., M.Sc., Ph.D.	Growth regulators

Phytopathology Section

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W. L. Seaman, B.Sc., Ph.D.	Seed-borne diseases
R. M. D. Sutton, B.A., M.A., Ph.D.	Bacteriophage and bacterial diseases

Virology Section

J. T. Slykhuis, B.Sc., M.Sc., Ph.D.	Head of Section Cereal viruses
L. N. Chiykowski, B.S.A., M.Sc., Ph.D.	Leafhopper-transmitted viruses
Y. C. Paliwal,[1] B.S.A., M.Sc., Ph.D.	Aphid- and leafhopper-transmitted viruses
R. C. Sinha, B.Sc., M.Sc., Ph.D.	Virus–vector relationships

Departures

A. R. Lacey, B.Sc. Transferred to Production and Marketing Branch, November 1967	Administrative Officer
D. C. Gillespie, B.S.A., M.S.A., Ph.D. Transferred to Fisheries Research Board, March 1967	Biosynthesis and metabolism
N. J. Hahn, B.Sc., M.Sc., Ph.D. Resigned June 1967	Genetic exchange
V. N. Iyer, B.Sc., M.Sc., Ph.D. Resigned September 1967	Mutagenesis and recombination mechanisms

VISITING SCIENTISTS

National Research Council postdoctorate fellows

J. Y. Lin, B.Sc., M.Sc., Ph.D., 1967–68	Bacterial biochemistry
A. Obayashi, B.S.A., Ph.D., 1965–67	Bacterial biochemistry
E. Strzelczyk, B.Sc., M.Sc., Ph.D., 1967–68	Soil microbiology

Graduate Student

M. K. Pomeroy, B.Sc., M.Sc. Research in partial fulfillment of the requirements for the Ph.D. degree in Biology, Carleton University, Ottawa.	Cryobiology

[1] Appointed October 1, 1967.

INTRODUCTION

The Cell Biology Research Institute was established on April 1, 1967. Its formation represents an enlightened step in research management, in tune with the times and in line with the rapid development of biological research the world over. It has become an axiom of modern biological science that significant problems can no longer be solved by unidisciplinary approaches. Scientists trained in a variety of disciplines will be required in the years ahead to approach common goals but from different points of view, if significant fundamental progress is to be made. The Cell Biology Research Institute was created to meet this challenge.

The function of the Institute is to conduct research on significant problems in cell biology to develop new backup knowledge, which is expected to be of considerable value in the ultimate solution of national agricultural problems. The primary materials used for study at present are: bacteria, fungi, yeasts, nematodes, insects, viruses, plants, and a variety of tissue culture types.

The professional and technical staff represent an amalgamation of all members of the former Microbiology Research Institute with the Frost Hardiness, Plant Biochemistry, Phytopathology, and Virology sections of the Plant Research Institute.

The research program of the Institute comprises only the starting point of a program, which remains to be developed and strengthened to become a more mature and balanced blueprint for the future. To this end, the knowledge, experience, and the creative talents of the entire staff will aid in shaping its developing program.

This report represents the results of the projects for which scientists now on our staff have been responsible during the calendar year 1967.

R. M. Hochster
Director

BIOCHEMISTRY

Metabolism and Enzymology of *Agrobacterium tumefaciens*

The respiratory system of Agrobacterium tumefaciens—It was clear from work done in this laboratory several years ago that a full understanding of the respiratory chain of this tumor-inducing organism of plants would only come when each of the components of the chain had been isolated and studied individually. Successful isolations can now be reported. Coenzyme Q_{10}, NADH-menadione reductase, cytochrome C_{551}, cytochrome C_{556}, and cytochrome b_1 were extracted, purified, and their properties studied in preparations from both tumorogenic and nontumorogenic strains.

The α, β, and γ bands of reduced cytochrome C_{551} occur at 551, 521, and 417 mμ, whereas those of cytochrome C_{556}, a separate molecular species, occur at 556, 525, and 417 mμ. It was also established that NADH-menadione reductase has FMN as its prosthetic group and that it can reduce cytochromes C_{551} and C_{556}, mediated by menadione as hydrogen carrier.

Cytochrome b_1 was purified extensively. It was found to have absorption maxima at 560, 528, and 426 mμ in the reduced form, was autoxidizable and only slightly reduced by menadione. Its locus in the respiratory chain and thus its physiological function remains to be clarified.

Although sonic extracts of the organism have extremely strong cytochrome *C* oxidase activity, their difference spectra, reduced minus oxidized and carbon monoxide (reduced) minus oxidized, provided proof for the existence of cytochromes a_1 and a_2.

Cytochrome C_{556} was found to have the unusual ability to bind carbon monoxide—in fact, its carbon monoxide difference spectrum was shown to be characteristic of what has been referred to as the cytochrome *o* – carbon monoxide complex. For

this organism, at least, it is not necessary to assume the existence of cytochrome *o* as has been customary for other organisms. Furthermore, cytochrome C_{556} is slowly autoxidized.

Although it was speculated some time ago that the components of the respiratory chain of *A. tumefaciens* might differ between tumorogenic and nontumorogenic strains of the organism, this was not borne out by the isolation studies reported above.

Enzyme regulation in glucose metabolism—Although the existing metabolic pathways for the oxidation of glucose in *A. tumefaciens* were established many years ago (Vardanis, A., and R. M. Hochster, 1961, Can. J. Biochem. Physiol. 39:1165–1182), efforts to understand the mechanisms of their control are now under way. Evidence obtained in the early phases of this work already shows that one of the branch-point enzymes, glucose-6-phosphate dehydrogenase, is allosterically inhibited by ATP, the energy donor that gives rise to its formation.

The enzyme was purified 1,000-fold by means of ammonium sulfate, protamine sulfate, calcium phosphate, and DEAE-G-25 Sephadex column chromatography. It was strongly inhibited by 30% glycerol, its molecular weight was calculated to be 260,000, and its pH optimum and K_m values were also determined. Current work concerns structural changes that appear to occur in the protein molecule during the process of inhibition.

In a different study, 6-phosphogluconic acid dehydrogenase, a second branch-point enzyme, was shown to be strongly inhibited by NADPH, the reduced product of the coenzyme that is responsible for 6-phosphogluconic acid formation. The inhibition was found to be competitive with NADP and very effective, displaying the inhibition constant K_i (for NADPH) of 2.5×10^{-6} M.

Important loci for the control of glucose metabolism have, therefore, been established, although details remain to be worked out.

Metabolism of amino acids (2)—The high specificity usually ascribed to the proline-concentrating system in bacteria does not apply in *A. tumefaciens*. A host of structurally unrelated amino acids inhibited proline uptake. Furthermore, tumorogenic and nontumorogenic strains differed both qualitatively and quantitatively in their proline-concentrating ability and in the effect of other amino acids on this system.

The concentration of each free amino acid present in hypocotyl tissue of sunflower seedlings was determined during the period after both sterile wounding and inoculation with either tumorogenic (strain 1025) or nontumorogenic (strain IIBNV$_6$) *A. tumefaciens*. The concentration of the total free amino acids of hypocotyl tissue reached a maximum 68 hr after infection with strain 1025 and this level was 50% greater than that found in plants treated with strain IIBNV$_6$. The total content of free basic amino acids increased to a peak value of 20 hr after infection by strain 1025 and this represented two to three times the level found in inoculated seedlings of strain IIBNV$_6$ at 20 hr. The amount of free proline decreased with time and was essentially absent 164 hr after infection with strain 1025. However, at 2 months, the free-proline concentration in tumor tissue was greatly increased with 75% of the total free amino acids accounted for as proline, which confirms earlier data obtained with tumor tissue of tomato and tobacco plants (Seitz, E. W., and R. M. Hochster, 1964, Life Sciences 3:1033–1037).

In a separate study designed to gain insight into the enzymology of proline formation and degradation in plant tumor tissue no unusual findings were made. The work confirmed what was known about the proline system in other tissues. Therefore, no clues are available, at the enzymatic level, to explain the enormous build-up of free proline in tumor tissue that is 2 or more months old.

Mode of Action of Myxin

Radioactive myxin (13)—Uniformly labeled ^{14}C-glucose of high specific activity was supplied to growing cells of a species of *Sorangium* (strain 3C) under specified conditions. The antibiotic myxin (1-hydroxy-6-methoxy phenazine-5,10-dioxide) was synthesized by fermentation and the product that was isolated contained ap-

proximately 10% of the ^{14}C supplied. The level of radioactivity in the final product could be increased significantly if ^{14}C-methionine (methyl-labeled) was also added. The purified, labeled antibiotic was used at low concentrations in experiments designed to show the site and mechanism of action of myxin with susceptible cells.

Mode of action of myxin on Escherichia coli (12)—Preliminary studies with actively growing *A. tumefaciens* cells indicated that DNA synthesis was strongly inhibited at a myxin concentration of 1 μg/ml without affecting the synthesis of either RNA or protein. A more detailed investigation into the effect of this antibiotic on DNA, RNA, and protein synthesis was undertaken with *Escherichia coli* as the test organism since, in this organism, the biosynthetic pathways have been well characterized. The susceptible strain 15T was used. The primary site of action was the inhibition of the biosynthesis of DNA (at a concentration of 5 μ/ml), quickly followed, as expected, by the cessation of RNA and then by protein synthesis.

The decrease in viable cell count was not pronounced until 13 min after exposure; that is, any lethal effect was largely reversible (by the titration procedure) up to this time. Extensive degradation of the DNA began at this time and was correlated with a rapid decrease in viable cells over the next 20 min. It would appear that, although DNA synthesis was extensively inhibited (90%) during the first 13 min, there was not sufficient damage to kill the cells. The degradation of cell DNA is either the result or the cause of cell death. The lethal effect of myxin could be due to a triggering action on a DNA degradative system, similar to that seen in the lysogenic strain $K_{12}(\lambda)$ of *E. coli* where myxin induces the synthesis of phage DNA, which subsequently involves the simultaneous degradation of host cell DNA.

At the concentration used, myxin was an effective bactericidal agent, but was effective only in its oxidized form. None of the effects described above were elicited by the reduced form.

The animal cells in tissue culture remained unaffected at these concentrations of myxin, in fact, myxin has been used effectively to prevent bacterial infections of such tissue culture material (personal communication from Dr. J. F. Morgan, University of Saskatchewan).

Enzymology of *Fusarium oxysporum*

Fructose-1,6-diphosphate (FDP) aldolase (9, 10, 11)—FDP-aldolase was purified 35-fold from crude extracts of the wilt-inducing fungus *Fusarium oxysporium* f. *lycopersici*. The catalytic properties of the enzyme suggest that it resembles the class II (yeast) type rather than the class I (rabbit muscle) type of enzyme. Treatments such as photooxidation, diazotization, and acetylation severely inhibit the cleavage reaction. Such inhibitory effects are prevented by glyceraldehyde-3-phosphate, one of the normal reaction products, and they do not affect the exchange capacity, which indicates that the amino acid residues that are altered are most probably concerned with the glyceraldehyde-3-phosphate, rather than the dihydroxyacetone phosphate site on the enzyme. The characteristics of the proton exchange reaction indicate that the latter becomes rate limiting with increasing pH and that it is mediated by a β-COOH of aspatate or a γ-COOH of glutamate.

Since the FDP-aldolase of the host plant is of the class I type and that of the pathogen is class II, these enzymes differ physically. It should, therefore, become possible to discover agents that will inhibit the enzyme in the fungus while leaving the plant enzyme intact. An enzyme-based approach to the effective treatment of wilt disease has now become feasible.

Release of Viral Genome in Infected Plant Cells

In vivo uncoating of tobacco mosaic virus protein (23)—With newly developed experimental techniques it was shown that one-quarter of the protein of tobacco mosaic virus is removed from the virus within 10 min of inoculation of tobacco leaves. This process gradually increases until about half the viral protein has been removed 3-4 hr after inoculation. The reaction proceeds as rapidly at 2 C as at room temperature and equally well in the presence of cycloheximide, a protein-syn-

thesis inhibitor. It even occurs, at least to some extent, in nonhost leaves. Thus, the reaction is nonspecific and probably not the result of preexisting or induced enzyme activity. The products of the reaction were established to be intact virus protein subunits or aggregates thereof.

Biochemical and Serological Taxonomy of the Fungi

Tyrosinase—This is a ubiquitous enzyme, which occurs in most plants and animals. Although the biochemical reaction catalyzed by the enzyme has been established, the biological significance of its function in disease, morphogenesis, sexuality of the fungi, radiation protection, and senescence is not understood.

Methods have been developed for comparative and taxonomic studies of isoforms of tyrosinase for the fungi. Polyacylamide gel electrophoresis has yielded six isoforms, five by immunoprecipitation and diffusion in agar and four by hydroxyapatite column chromatography. These isoforms are being studied physically, catalytically, and immunochemically as they relate to the phytogenesis and ontogenesis of the polyporaceous fungi.

Preliminary tyrosinase comparisons have been completed for seven organisms, and an inhibitor of tyrosinase activity has been discovered in *Agaricus campestris*.

CRYOBIOLOGY

Frost Hardiness

24, 25, 26

The living bark of the black locust tree has been used as a model system for studying the chemical mechanism of frost hardiness in plants. Studies have shown that replication of total protoplasmic substances including organelles such as mitochondria and microsomes is part of the hardening mechanism in the black locust tree. The most recent studies have shown increases in hardiness also in phospholipids and lipoprotein, thereby implicating, in addition, the membrane components of the cell in the total protoplasmic augmentation reaction.

Environmental photoperiod studies in constant-temperature chambers indicate the importance of endogenous rhythms in the hardiness reaction. Studies in testing and selecting hardy winter wheats produced in a breeding program in cooperation with the Ottawa Research Station have yielded hardier experimental varieties of winter wheat. They have also contributed to a better understanding of the environmental factors affecting hardiness in this plant.

Research into methods of insulating crop plants against frost damage has led to the exploration and successful application of newly formulated, protein-based, fire-fighting foams for the complete protection of tomato plants in the field against overnight frost damage.

CYTOLOGY

The Role of *Arthrobacter* spp. in the Soil

Fine-structure—Electron microscopic studies were continued on the internal organization of the pleomorphic soil arthrobacters. Particular attention was paid to the development, structure, and potential function of the mesosomes—the intracellular membranous organelles prevalent in these organisms. The mesosomes were present at all stages of the life cycle, but they varied from a simple tubular structure in aged cells to large complex tubular-vesicular bodies in young, actively dividing cells. Thin-sectioning and negative staining procedures showed that mesosomes can occur throughout the cell. They were found frequently in close association with the nuclear bodies and were always present at the sites of septa formation.

Cells induced with succinate in the presence of organic or inorganic hydrogen acceptors that are insoluble in the reduced form (tetrazoliums, tellurite) showed deposition of the acceptors only in the mesosome. Apparently the mesosomes are multifunctional and cytological evidence shows their potential part in the divisional process through laying down of the cell wall or as genome separators, while cytochemically they are shown to be the sites of oxidative–reductive enzyme activity.

ELECTRON MICROSCOPE CENTER

Establishment of the Cell Biology Research Institute has brought the Electron Microscope Center under the control and operation of this institute. It will be managed as a Research Branch facility, available to all the Research Institutes and Services.

While a drive to recruit expert staff continues in this highly developed and specialized area, the facilities of the Center have been made available to those who needed them most. During 1967, 10 main, active research projects were pursued with the aid of electron microscopes: four within the Cell Biology Research Institute; three by the Entomology Research Institute; and three by the Ottawa Research Station. At the moment three additional projects are being planned for immediate inclusion in the program of the Center.

The facilities of the Electron Microscope Center have played an ever-increasing part in the support of studies in a wide variety of biological disciplines. For example, some of the active projects include work in: Virology (viruses *per se*, insect vectors and host tissues), Microbiology (fine-structure of bacteria and fungi, locomotion), Entomology (fine-structure of nematodes, reproductive systems, cell membranes), Plant Pathology (site of fungal infections), and Genetics (fine-structure of replicating DNA and mutagenic effects). Preliminary studies have also been undertaken on electron diffraction of soils, circulatory systems in insects, and transmission of bee diseases.

MICROBIAL ECOLOGY

Rhizosphere Bacteria

Foliar sprays and the rhizosphere effect—The alterations that occur in the root-zone microflora when selected compounds were applied as foliar sprays to certain crop plants have been studied further. The antibiotic myxin, when applied as a foliar spray to soybeans at a concentration of 50 μg/ml, caused a threefold increase in total numbers of bacteria as well as a significant shift in the equilibrium of the various genera of bacteria present. The percentage incidence of the metabolically active Gram-negative groups was increased markedly, whereas the incidence of slower growing types decreased. The results suggest that the myxin spray caused metabolic changes within the plant that resulted in an alteration of the chemical composition of root exudates and caused a shift in the relative proportions of microorganisms on the root surface.

Coryneform bacteria in soil—Studies on the types and distribution of coryneform bacteria in soil showed that the percentage incidence of this type of organism in root-free soil was about twice that in the rhizosphere. Based on morphology these organisms were divided into three main groups: the first (typical of the genus *Arthrobacter*), in which a complete cycle of development was observed within 24 hr (i.e., coccoid forms enlarged and exhibited a mixture of rod-shaped cells of irregular size and shape and reverted again to coccoid forms); the second, in which the growth cycle was not completed for 5–7

days; and the third, in which the reversion to the coccoid form was never complete.

The *Arthrobacter* types accounted for approximately 60% of the soil coryneforms and 40% of those from the rhizosphere. A nutritional grouping demonstrated only slight differences between isolates from the rhizosphere and those from root-free soil. Most of the *Arthrobacter* types, however, were able to grow well in simple growth media, whereas the slower growing forms required the more complex ingredients of yeast and soil extracts for maximum growth. When tested for their ability to use a number of carbon compounds and aromatic hydrocarbons there were no apparent differences in utilization patterns between rhizosphere and soil populations. It was apparent that the coryneform types of soil bacteria were suppressed to some extent in the root zone and that there was no selective stimulation of any particular morphological or nutritional group.

Rhizosphere Fungi

Soil amendments—The favorable effect of soil amendment with soybean meal on nematode-trapping fungi in the vicinity of plant roots has been reconfirmed. Increases in the incidence of *Arthrobotrys oligospora* Fres. occurred in the rhizosphere of soybean, tomato, and wheat grown in natural soil treated with soybean meal. The greatest response occurred with soybean seedlings and the least with wheat seedlings. The fact that the number of free-living nematodes in the soybean root zone was about 200 times greater than the number for wheat suggests that this difference may be due mainly to the relative abundance of prey.

Miscellaneous Observations on Myxin

Inactivation of the phenazine antibiotic myxin occurs very rapidly in natural soil. The biological activity of small doses of myxin in a silt loam was reduced by 50% in 24 hr and only a trace of activity was detectable after 48 hr exposure.

In vitro sensitivity tests showed the antibiotic to be highly active against a number of different strains of the Dutch elm disease fungus, *Ceratocystis ulmi* (Buism.) C. Moreau.

Numerical Taxonomy of Soil Microorganisms

Numerical techniques were used to study the taxonomy and ecology of soil and rhizosphere bacteria. The clusters derived by means of an extensive computer study, representing associations between the constituent organisms, were taxonomically credible. The taxonomic aspects of the studies have prompted further comparative studies among the arthrobacteria, the agrobacteria, and the rhizobia. The results showed that numerical data-condensing techniques can be used successfully for studying the ecology of soil heterotrophic bacteria. It was concluded that the etiology of microbial selection in the rhizosphere must await the availability of more extensive data.

PHYSIOLOGY

Host-specific Toxins

Host-specific pathogen-produced determinants of disease (17, 18, 39)—The old and elusive problems of the chemical bases of pathogenicity and virulence in infectious microorganisms and of disease resistance in plants are being clarified by modern techniques. The significant role of host-specific toxins in disease development in important agricultural crops, which had already been established in oats and sorghum, was found to extend to corn.

Helminthosporium carbonum Ullstrup, the causal agent of a leaf blight of certain corn hybrids and inbred lines, was found to produce a host-specific toxin that is capable of reproducing all the symptoms of the disease in susceptible plants. This toxin has been isolated, purified, and crystallized. It is harmless to resistant cultivars and other nonhost plants, but is very toxic to susceptible corn cultivars.

Periconia circinata (Mangin) Sacc., the causal fungus of a blight of certain culti-

vars of sorghum, was found to produce more than one host-specific toxin. Culture filtrates of the fungus grown at different times contained toxins that differed in chemical composition, but that were still specifically toxic only to plants susceptible to the pathogen. Two distinct host-specific toxins, which could be separated by ion-exchange column chromatography or countercurrent distribution, were named *P. circinata* toxins A. and B. When they were hydrolyzed, both yielded amino acids.

Physiology of Growth Control

Studies on the mechanism of the rest period (31)—The development of flowers in rhododendrons is interrupted by an indeterminate rest period. The onset of rest and the maintenance of rest are controlled by the flower bud scales. These scales are also involved in the phenomenon of apical dominance. The effects of the scales on the rest period in situ were also demonstrated in vitro. The mechanism of rest is being studied in vitro and in situ. Growth regulators were extracted from growing and from resting flower buds and tested in an *Avena* coleoptile elongation test. This is a biochromatographic assay, which was developed for the quantitative analysis of growth-promoting and growth-inhibiting substances in plant extracts. One of the regulators inhibited growth in the coleoptile test, but when supplied to a test solution with low concentrations of indole-3-acetic acid, it promoted growth in excess of what was expected. The synergistic activity of this material in a growth test differed greatly from the activity reported for other growth regulators. Preliminary tests showed that the compound is present in resting buds, but that it is absent in growing buds. Efforts are being made to characterize this compound and to test it in the in vitro system. Its relevance to the phenomenon of dormancy is also under study.

PHYTOPATHOLOGY

Soil- and Seed-borne Diseases

Environmental and species relationships in Ascochyta (21, 22, 37, 38)—The most significant contribution in this area of research was the finding that certain important diseases of peas are soil-borne. The diseases, blight caused by *Mycosphaerella pinodes* and foot rot caused by *Ascochyta pinodella,* were formerly regarded only as seed-borne and their importance as pathogens was attached only to this phase. These organisms have now been isolated from many soils using a selective medium. The foot rot pathogen was found in most soils in which peas were growing, but also in some soils where peas had not been grown for 1–5 years. Soil cultures of *A. pinodella* were weakly virulent, but, by host passage, reisolated cultures produced typical symptoms of foot rot in young plants. *M. pinodes* was isolated less frequently from soil. Cultures were strongly virulent, however, and inoculated plants showed typical disease symptoms in 5 days. *M. pinodes* was isolated from the soil of fields that had not grown peas for over 20 years. These isolates were strongly virulent. Although infected seed has in the past been considered to be the main source of inoculum, the frequent isolation of *A. pinodes* and *A. pinodella* from soil demands a reappraisal of the epidemiology of this disease complex.

Since 1961, the incidence of blight in pea seed has increased steadily. Therefore, research was started to control the internally seed-borne infections. Two fungicide compounds, thiram and captan, were found to control the organism in the seed when the treated seed was grown in sand, sandy loam, or sterilized sandy loam.

The first successful use of radio-frequency electric fields for the elimination of pathogenic fungi from the interior of infected seed without prohibitive damage to the host has been accomplished. Such fields were found to be effective in eradicating fungi from infected seeds of soybeans and peas. *Diaporthe phaseolorum* (Cke. & Ell.) Sacc., the causal agent of pod and stem blight, was eliminated from soybean seed by brief exposure to radio-

frequency electric fields of 59 Mc/sec with little reduction in seed germinability. Survival of *Ascochyta* spp. in pea seed was greatly reduced in similar treatment, but was accompanied by somewhat greater loss in seed viability. Both fungus and seed were increasingly susceptible to damage by such treatment at seed moisture contents above 10%. Phytopathogenic bacteria were killed by exposure to radio-frequency electric fields in vitro, but survived exposures that were fatal to their seed hosts.

Bacterial Diseases

Fuscus blight of beans (1)—The brown, diffusible pigment produced by *Xanthomonas phaseoli* var. *fuscans,* the causal organism of fuscus blight of beans, was shown by a variety of microchemical techniques to be melanoid in nature. Pigment production depended on temperature, degree of aeration, and carbon sources in the media. A number of simple sugars such as glucose, galactose, and mannose inhibited pigment formation, but their corresponding sugar alcohols did not. The growth rate of the organism was not affected at all by the addition of the pigment-inhibiting sugars.

Bacteriophage

Experimental phage typing (36)—An experimental phage typing system was developed with which 8 phage types and 17 phage subtypes of *Xanthomonas phaseoli* (E.F. Sm.) Dowson (bacterial blight of beans) have been identified. Phage subtypes were identified with high-titer phage preparations and could be located geographically. Correlation between strain virulence and phage subtype was demonstrated. The incidence, distribution, and low ecological significance of phages for *X. phaseoli* and its varietal form of *fuscans* in soil samples from southwestern Ontario, a principal bean-growing area, have been demonstrated. The ecological and epidemiological shift from the high incidence of strains of *X. phaseoli* var. *fuscans* to their near exclusion in favor of strains of *X. phaseoli* between 1961 and 1967 was established.

Fifty strains of *Xanthomonas* (32 "species" of bacterial plant pathogens) have been examined for lysogeny and for their capacities to produce lytic phage particles by ultraviolet irradiation, chemical treatment, and their pairwise (mixed culture) combinations (all 50 strains were used as indicators in the phage tests). Computer analyses of the results of over 125,000 tests show that only two strains were normally lysogenic, whereas 46 fertile pairwise combinations were produced; five of these combinations were lytic to one of the parental strains. The results also show that many of the phages elicited in the pairwise combination studies were the products of mechanisms other than those understood at present.

VIROLOGY

Viruses Affecting Cereals and Other Grasses

15, 40, 41

A new virus, tentatively named wheat blight virus, was found in two grasses, *Poa palustris* L. and *Agropyron trachycaulum* (Link) Malte, in Alberta. It causes leaf necrosis and often quickly kills plants of wheat, oats, barely, and rye. Plants that survive are severely stunted and their leaves have a chlorotic mottle and are usually crinkled and twisted. The virus causes only mild to moderate mottling on several perennial grasses. The particles have been examined under the electron microscope and have been found to be short rods. The virus is related serologically to the seed-borne barley stripe mosaic virus, but attempts to transmit it through seed have failed.

Isolates of another virus from *P. palustris* in Alberta and from *P. pratensis* at Ottawa have flexuous rod-shaped particles and are readily transmitted to oats.

In a search for natural reservoirs of wheat streak mosaic virus, the virus but not its vector was found on a perennial

grass, *Alopecurus aequalis* Sobol., in Alberta.

Kernel red streak of corn, which has been widespread in southwestern Ontario since 1964, was induced experimentally in field corn at Ottawa by infesting ears with either viruliferous or nonviruliferous eriophyid mites (*A. tulipae*) from wheat.

Leafhopper Transmitted Plant Viruses

Host studies (4, 5, 6)—Clover phyllody virus (CPV) was transmitted by the leafhoppers *Macrosteles fascifrons* (Stål) and *Aphrodes bicinctus* (Schrank) to 34 species of plants in 13 families. Forty-five other species of plants in 12 families showed no infection. *M. fascifrons* also transmitted CPV from 17 of 18 infected plant species, including perennial, biennial, winter annual, and annual species.

Seven varieties of wheat (*Triticum aestivum* L. and *T. durum* Desf.) exposed to viruliferous *M. fascifrons* were found susceptible to a celery strain (CAYV) and a noncelery strain (NAYV) of aster yellows virus. NAYV infected 42% of the plants tested, whereas CAYV infected only 11%.

Vector – virus – host plant transmission studies (28)—Transmission of CPV by *M. fascifrons* was influenced by sex and age of insect at the time of acquisition access feeding. When fed as adults, males transmitted much less efficiently than females. When fed as nymphs, however, males were only slightly less efficient. The availability of virus in infected asters, as determined by the percentage of insects transmitting after a 3-day acquisition access feed, remained relatively constant for 10 weeks after the appearance of symptoms. Transmission by unsexed adult leafhoppers fed on various parts of infected asters was: basal stem 60%, upper stem without leaves 54%, upper stem with leaves 46%, flowers 35%, and basal leaf 10%.

Relationship of Certain Viruses to their Leafhopper Vectors

27, 29, 30

Wheat striate mosaic virus (WSMV) was shown to multiply in its leafhopper vector, *Endria inimica* (Say), by using the serial injection technique. Unlike any other leafhopper-borne virus, WSMV reaches a peak concentration before the end of the incubation period of the virus in the insects—a property shown by several animal viruses. The virus could be detected in the alimentary canal, brain, salivary glands, fat body tissues, hemolymph, and hemocytes of viruliferous leafhoppers by serological or infectivity tests. This suggests that the virus is capable of multiplying in several tissues of the insect vectors.

The susceptibility of certain cells of the alimentary canal of the leafhopper vector, *Agallia contricta* Van Duzee, to wound-tumor virus decreases as the insect ages, as determined by immunofluorescent techniques. The spread of infection from the alimentary canal to the hemolymph and to the salivary glands of the leafhoppers, a necessary condition before an insect can transmit the virus, was prevented by maintaining the leafhoppers at 36 C after they had acquired the virus from infected plants.

The alimentary canal of the leafhopper vector, *M. fascifrons,* was shown to be the initial site of aster yellows virus infection and multiplication, and it is possible that hemocytes may be the main sites of virus synthesis. It was found also that the virus concentration in salivary glands must increase up to a certain level before an insect can transmit the virus to plants. The virus was shown to multiply in the nonvector leafhopper, *Agallia quadripunctata* Provancher, but, in this case, the only site of virus infection and multiplication was the alimentary canal.

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B. V. Peterson, B.S., M.S., Ph.D.	Diptera: Simuliidae, Nycteribiidae
J. R. Vockeroth, B.A., M.A., D.Phil.	Diptera: Syrphidae, Scatophaginae
J. F. McAlpine, B.S.A., M.Sc., Ph.D.	Diptera: Lonchaiidae, Chamaemyiidae
H. J. Teskey, B.Sc., M.S.A.	Diptera: Tabanidae, larvae

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[2] Honorary Research Associate.

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L. A. Kelton, B.S.A., M.Sc., Ph.D.	Hemiptera: Miridae
W. R. Richards, B.Sc., M.Sc., Ph.D.	Hemiptera: Aphididae
F. Schmid, Lic. ès Sc. Nat., D. ès Sc. Nat.	Trichoptera
E. E. Lindquist, B.S., M.S., Ph.D.	Acarina

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D. R. Oliver, B.A., M.A., Ph.D.	Ecology and faunistics of arctic insects
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J. C. Guppy, B.S.A., M.S.	Ecology of forage-crop insects
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B. N. A. Hudson (Miss), B.Sc., Ph.D.	Physiology of mosquitoes
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Nematology Section

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B. E. Hopper, B.S., M.S.	Taxonomy, ecology
R. V. Anderson, B.A., M.S., Ph.D.	Taxonomy

Apiculture Section

T. A. Gochnauer, B.A., M.S., Ph.D.	Chief of Section Pathology
R. Boch, Dr. rer. nat.	Physiology, behavior

Departures

W. J. Brown, B.A., M.Sc. Retired 1967	Coleoptera: Chrysomelidae, Coccinellidae
J. G. T. Chillcott, B.S.A., Ph.D. Died 1967	Diptera: Muscidae, Empididae, Rhagionidae
P. S. Corbet, B.Sc., Ph.D., D.Sc. Transferred to Research Institute, Belleville, Ont., 1967	Experimental ecology of aquatic insects
B. Furgala, B.S.A., M.Sc., Ph.D. Resigned 1967	Physiology and ecology of bees
J. G. Robertson, B.Sc., M.A., Ph.D. Died 1967	Genetics: cytotaxonomy

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VISITING SCIENTISTS

L. J. Bottimer, B.S. — Coleoptera
Research Associate

W. Hennig, Ph.D. — Diptera
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A. Smetana, M.U.Dr., Cand. Sc. Biol.
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INTRODUCTION

The Entomology Research Institute is responsible for research and special services in a wide field related to the Canadian fauna of insects, arachnids and other land arthropods, and nematodes. The Institute maintains and develops the Canadian National Collections of these groups of animals; it provides a national identification service; and it carries out an extensive program of research. The work of the Institute plays a substantial role in crop and forest protection, in human and animal health, and to a gradually increasing extent in relation to natural resources and conservation.

The research work is reported under two main headings: the one Taxonomy and the other Bionomics and Physiology. The two groups of studies are closely related and together aim at describing and understanding the Canadian fauna as regards its content, its origin, and its biological significance. There is no suggestion that the Institute achieves these aims except in a very incomplete fashion; the number of species of insects is approximately twice as great as the number of all other kinds of organisms taken together.

Two collecting parties of unusual interest were in the field last summer, one in Nepal and the other on Sable Island, off the coast of Nova Scotia. The material collected on each of these expeditions will make its own distinctive contribution to a broad understanding of the origins of the Canadian fauna.

An insect morphologist was appointed, who will work with taxonomists on the general aspects of classification.

The steady development of the National Collections yields its own problems, of which the most serious is that of technical support both for the researches conducted by the scientific staff and for the curation of the collection as such, regarded as a national treasure and an indispensable tool in the identification service. The development of the experimental program likewise calls for extended facilities for biosystematic work and increasingly complex equipment for studies of behavior and physiology. Most of all, perhaps, the Entomology Research Institute would benefit by being gathered together in one place, so as to make the greatest use of the wide range of skills and disciplines among its members.

During the year Dr. Philip S. Corbet, a distinguished ecologist, transferred to become the Director of the Research Institute, Belleville. Unhappily, the Institute also lost two valued members by death: Dr. J. G. Chillcott, the head of the Diptera Unit and a well-known taxonomist; and Dr. J. G. Robertson, a geneticist engaged in very interesting cytological studies. To the families of both we extend our sincere sympathy.

G. P. Holland
Director

TAXONOMY

Surveys and Collections

19, 27, 33, 69

The Canadian National Collections (C.N.C.) have continued to grow, as a result of field work by officers of the Institute and by gift and purchase. Eighteen officers devoted 145 man-weeks to field collecting. Surveys were conducted in Western Canada for Coleoptera, Diptera, and Hymenoptera; in southern Ontario for Lepidoptera; locally in the Ottawa–Gatineau area for various groups; and in the Maritime Provinces for Diptera and Homoptera. Five men spent 5 weeks in general collecting of insects and nematodes on Sable Island, which may have been a biotic refugium during the Pleistocene glaciations. Collecting trips for nematodes were made to various areas of Ontario, Quebec, and the Maritime Provinces, and the expedition to Sable Island yielded several groups not previously reported from Canada.

In the United States, surveys were made in Florida for Coleoptera, Diptera, and Heteroptera; in Colorado and California for Lepidoptera; and in the Hawaiian Islands mostly for Diptera.

A two-man party made extensive general collections in the high and middle altitudes of Nepal for 4 months. These collections will be invaluable in furthering studies on the interrelationships of the insect faunas of the Old and New Worlds.

A European collection of about 25,000 parasitic Hymenoptera, mostly Ichneumonidae, was purchased; over 1,600 named species, representing over half the known species of Europe, were included, and at least 1,000 were new to the C.N.C. The W. C. Cook collection of some 20,000 nearctic noctuid moths, representing about 1,500 species, was purchased. A collection of 880 ants, comprising 213 named species, was donated by Dr. W. S. Creighton. The addition of 140 named species of South American scolytid beetles greatly augmented the neotropical representation of this group in the C.N.C.

Identification and Information Services

About 755 shipments of insects and arachnids, comprising some 30,000 specimens, were received for identification. As in past years, the Department of Forestry and Rural Development submitted about twice as many specimens as the Department of Agriculture (44% and 23% respectively of the total number of specimens submitted), although again in few shipments. The substantial remainder, 33% of the specimens, attests to the considerable amount of service work that is carried out at the request of other organizations and for the general public.

A total of 269 soil and plant samples infested with nematodes were also submitted for identification. About 80% of these were submitted by the Plant Protection Division and the remainder from numerous institutional and private sources.

Taxonomic Investigations

Thirty-five publications in the taxonomic field include revisions, descriptions, or biological information relating to approximately 470 species (77 new to science) in 155 genera (7 new), and representing 42 families of insects. Notes on these publications, and on significant works in press, follow.

Coleoptera (6–10, 12–14, 35, 41, 42, 48)—In the Scolytidae, the types of the North American species described by Swaine were catalogued; the holotypes of 62 species were listed, and lectotypes for 48 other species were designated. Lectotypes were also selected for two of Chamberlin's species. The genus *Cactopinus* with seven species was reviewed, and a new genus was proposed for two other closely related species.

In the Coccinellidae, a key to the six forms of *Coccinella* that occur in Mexico was published with notes supplementing an earlier revision of the genus in America north of Mexico. In the Scarabaeidae, a new species of *Geotrupes,* and the larva and life history of a species of *Ceratotrupes* from Mexico were described.

A revision of the staphylinid subfamily Micropeplinae, a review of the scarabaeid

subfamily Trichiinae, and two papers on the identities of seven economically important species of Bruchidae have been completed.

Diptera (54, 55, 68, 70, 71, 93, 97–99)—Owing to the untimely death of Dr. J. G. Chillcott, the projects on the systematics of the Rhagionidae and Muscidae were terminated.

The work for the proposed new Manual of North American Diptera similarly had to be reorganized, and is now proceeding under new leadership. The systems of classification and terminology for the Manual were reviewed in 10 work conferences, in which Professor W. Hennig, of Stuttgart, participated; and manuscripts for 25 families have been received.

The peculiarly assorted primitive and specialized characters of the only known species of the family Ironomyiidae were illustrated and comparisons were made with the Empididae, Platypezidae, and other possibly related groups.

A new species of Chloropidae, reared from bracket fungi in the Ottawa area, was described. In the Tabanidae, a newly described species of *Chrysops* from eastern North America was compared with a previously described sibling, for which a lectotype was designated. The four syntypes of a chamaemyiid, *Leucopis annulipes* Zett., were found to represent three species; the identity of the nominal species was established, and the confusion which persisted in the literature concerning *annulipes* for over a century was clarified.

Hemiptera (11, 45, 73–81)—A memoir was published on the aquatic and semiaquatic Heteroptera of the Prairie Provinces that includes keys, illustrations, descriptions, and biological and distributional data for 95 species in 12 families. The nine species of the anthocorid genus *Lyctocoris* in North America were also reviewed.

In the Aphididae, the eight species of *Tinocallis,* the three species of the nearctic genus *Tamalia,* and the six Canadian species of *Pterocomma* were reviewed. The phyletic position of the Pterocommatini was reevaluated, and it seems now that they are a specialized rather than a primitive group. One new species each of *Macrosiphum* and of *Aulacorthum* from British Columbia were described. A synopsis of the 30 species of *Myzocallis* of the world has been completed.

Hymenoptera (51–53, 57, 85, 100)—Eight species of parasites reared from larvae of the eye-spotted bud moth were reviewed. An illustrated key to the remains of the last-instar larvae within the host cocoon was constructed and provides a means of assessing the effect of parasitism on populations of the moth without rearing the parasites to adulthood.

A study of the egg-stalk structure of nine species of ectoparasitic ichneumonids of the genus *Exenterus* showed an evolutionary sequence from a single small and fragile stalk to a highly specialized, enlarged, and strongly protective double stalk, which does not become brittle in dry climates. The ranges and abundance of the European species introduced into North America for biological control seem to be correlated with the level of specialization of this structure.

Three species-groups were established in the ichneumonid genus *Diadegma,* and the 12 nearctic species, 10 of them new, were reviewed.

Lepidoptera (4, 21–26, 32, 34, 49, 63–67, 88)—Annotated and illustrated keys to the larval behavior and mines of 28 species of nearctic leaf-mining Lepidoptera on conifers were published, along with distributional notes. The adults of six conifer-feeding species of the tortricid genus *Choristoneura* were described and a tabulated summary of the distribution, ecology, and color characters of each species was appended. The olethreutid genus *Zeiraphera,* with nine nearctic species associated mainly with conifers, was reviewed.

In the Pyralidae, a taxonomic study of about 60 species of neotropical Crambinae included the descriptions of 4 new genera and 37 new species. Four new species of *Udea,* and a new genus and species of Pyraustinae were described from South America, and another new pyraustine genus with two species was described from Malaysia. The generic status of *Thliptoceras* was clarified; 20 previously described nominal species were referred

to this genus, and 13 of them were recognized as valid; lectotypes were designated for 7 species.

Descriptions of the developmental stages and observations on the adult and larval activities of the noctuids *Schinia felicitata* (Smith) and *Helilonche carolus* McDunnough have been completed. In the Gelechiidae, a new species of *Exoteleia* was described from Canada, and a species-group of *Chionodes* with six species was reviewed.

A revision of the North American Aegeriidae, based on the taxonomy of late-instar larvae, has been completed. The larvae bore in the stems and roots of many plants and, because they are difficult to rear, their identification in this stage is more than usually important. Sixty species distributed in 20 genera were available for study, and five tribes grouped into two subfamilies have been recognized.

Other insects and arachnids (48, 84, 89–92)—Several comprehensive treatises on Trichoptera are in press: a memoir on the genus *Rhyacophila* and the family Rhyacophilidae; a study of a new genus of Leptoceridae, including 17 new species; and a memoir on the family Arctopsychidae.

In the Collembola, a study of the generic classification, evolution, and biogeography of the Sminthuridae of the world is in press. Thirty-one genera grouped into four subfamilies are recognized. The evidence suggests that the family originated in the northern hemisphere and that the units now recognized as genera were probably in existence before the end of the Cretaceous period.

An invitation paper on mites and the regulation of bark beetle populations was given at the Second International Congress of Acarology, and is now in press.

Nematoda (1, 2, 36, 37, 60–62, 87, 101–103)—The revision of the predaceous soil-living nematodes of the family Mononchidae has been continued, with accounts of the genera *Mononchus* and *Prionchulus,* based on material of world-wide distribution, and a general study of the Nigerian fauna. Four of the 10 genera found in Nigeria were new to science.

A new species of gall-forming nematode, *Anguina calamagrostis* Wu, 1967, has been described from blue-joint grass. The term *crustaformeria* was introduced for the region of the reproductive tract where the eggshell is formed, and it was shown that this structure, and also the spermatheca and the sperm cells, could be used as diagnostic features on the generic level. Various other anatomical characters were introduced for the first time into taxonomic work in the Mononchidae, the Hoplolaiminae, and the marine Cyatholaimidae. However, experiments on *Acrobeloides nanus* (de Man, 1880) Anderson, 1968 have shown that certain characters that were previously regarded as stable are readily modified by environmental conditions and cannot be used directly for diagnosis at the specific or even at the generic level.

Biogeography

12, 84, 93

A study of the insect fauna around seaports in the Atlantic Provinces of Canada showed that many beetles immigrated with man from Europe, mainly during colonial times. Four of the 34 species listed as probable immigrants were reported from North America for the first time.

Two previously known species of leaf-mining agromyzid flies were recorded from Easter Island, an isolated island in the Southern Pacific. The example shows that the insect associates of common cultivated plants in poorly known faunal regions should be suspect as "new" species until the possibility of colonization with their host plants has been investigated.

In the Plecoptera, an analysis of the variation and distributions of three subboreal species of *Allocapnia,* a genus of winter stone flies, suggests that these insects inhabited the Cumberland Plateau region during the Wisconsin glaciation, and colonized the subboreal parts of Eastern Canada after the glacial period.

Ecology of Crop and Forage Insects

28–31

The population (life-table) studies of the *Plutella maculipennis* (Curtis), *Pieris rapae* (L.), and *Leptinotarsa decemlineata* (Say) have been transferred from the Merivale plots to a new site at Richmond, Ont., with comparative plots being maintained also at the Central Experimental Farm. The new arrangement allows local and seasonal effects on populations to be observed. An attempt to relate the current life-table studies on insects to the understanding of human populations was made in an invitation paper recently published.

The distribution of eggs of the cabbage root maggot, *Hylemyia brassicae* (Bouché), has been studied under field-plot conditions. A simple plan of sequential sampling of the population has been developed, and the probable level of an infestation can be estimated in time for appropriate control measures to be applied.

The complexity of the factors that affect insect populations is well illustrated by the recent study that listed 69 species of parasites known to attack the armyworm, *Pseudaletia unipuncta* (Haworth).

Ecology of Nematodes

38–40, 56

An extensive study of the ecology of marine nematodes has recently been carried out in collaboration with the University of Miami. Upwards of 100 species were found in turtle-grass beds, an important inshore habitat of warm Atlantic waters. Spatially the fauna is homogeneous in general aspect, but closely related species of similar ecological type tend to replace one another according to minor differences in the habitat. There is also an evident seasonal cycle, which affects both numbers and species composition. It appears that most previous surveys of marine nematodes, even those carried out by precise quantitative sampling, are substantially defective for lack of consideration of the spatial and temporal variability.

Bionomics of Bees

5, 46, 47, 57, 58, 94–96

The study of pheromones in the social life of bees has been continued. The primary alarm pheromone in sting glands of *Apis mellifera* Linnaeus, isopentylacetate, has been recovered in large amounts from *Apis dorsata* Fab. and in lesser amounts from *Apis indica* Fab. and *Apis florea* Fab., the three Asiatic species of honey bees. The alarm substance in the mandibular gland, 2-heptanone, is found only in *A. mellifera*, and is restricted to the workers that guard the nest or forage for food.

Honey bees' combs contaminated with European foulbrood disease were treated with gamma radiation from a Co^{60} source. The infection was reduced in proportion to the dosage, but the maximum level applied (0.2 megarad) was not completely effective.

The chemical characterization of the oligosaccharides of honey was concluded. The significant recent findings includes two β-linked disaccharides, gentibiose and laminaribiose, and the discovery of two new trisaccharides, 2-α-maltosyl glucose (centose) and linear 4-α-gentiobiosyl glucose. The number of oligosaccharides known to occur in honey now stands at 26. Raffinose was not found in honey, and sucrose accounted for less than 0.1% of the total sugars. The use of sucrose as an indicator of adulteration of honey is thus confirmed.

A method of overwintering the bumblebee *Megabombus fervidus* (F.) under artificial conditions was developed. It seems that the amount of fat body present before hibernation is an important factor in winter survival.

Regulation of Sex in Hymenoptera

The continuing study of the processes involved in the regulation of sex in the parasitic wasp *Dahlbominus fuliginosus* (Zett.) has focused mainly on the functioning of the spermathecal system and on the numbers of sperm deposited by the male and reaching the spermathecal capsule.

Functional Histology

3, 86

In the giant cockroach there are four morphologically distinguishable types of cells in the blood. It has been shown that two types, the granular hemocytes and the spherule cells, are distinguished from the other two by a capacity to concentrate mucopolysaccharide in the cytoplasm. They are distinguishable by the nature and amount of the cytoplasmic globules.

Under certain conditions it appears that the relative abundance of the four categories of hemocytes changes between light and darkness. These changes are now being investigated more fully; they presumably reflect changes in metabolism related to the state of activity of the insect.

The physiology of an entomophagous internal parasite, *Aphaereta pallipes* (Say), continues to be a main center of interest. The embryo is surrounded by a trophamnion, through which all exchange of materials must be effected. The surface of the trophamnion is covered by microvilluslike extensions that appear to engulf droplets from the host's blood by pinocytosis, but how this material is transferred to the embryo is not yet clear. The chorion, by contrast, is thin and has a spongy fibrous ultrastructure that presumably poses no barrier to exchange of nutrients. This and other physiological studies now in progress have been greatly aided by the introduction of electron micrographic techniques.

Bionomics of Biting Flies

15, 18, 20, 44

It was suggested earlier that the original Diptera possessed mandibles and an elongate proboscis, which together formed a cutting and sucking apparatus much as in the black flies and biting midges of today; most existing Diptera, however, have lost the mandibles and the ability to pierce the integument and ingest fluids from a host. The presence of fully developed biting and sucking mouthparts has recently been discovered in two families in which it was previously unknown; in the Tanyderidae, recognized on other grounds as one of the most primitive in the order, and in the Chironomidae, a large group of midges hitherto reckoned as nonfeeding and short-lived in the adult stage, but closely related to mosquitoes and black flies. Therefore both the new discoveries conform reasonably to expectation.

The mosquito *Aedes atropalpus* (Coquillett), although it belongs to a family mainly of active biters, needs no blood meal in the first ovarian cycle, and a full complement of eggs develops to maturity within 3 days of emergence. The physiological changes during the reproductive cycle are being investigated. A fine standardized pipette has been designed and made in the laboratory, and it is now possible to take an accurately measured quantity of hemolymph from a single mosquito and to determine the concentration of sugar or other metabolites. Trehalose appears to be the predominant blood sugar in the newly emerged female, and occurs at a concentration of about 30 g/liter, while reducing sugars are present at about 5 g/liter.

Arctic Insects and Their Environment

15–17, 59, 68, 69

Analysis of the material and observations obtained at Hazen Camp and in Peary Land has continued. Arctic Chironomidae usually remain in the larval stage for more than 1 year. The duration of the larval period is not always determinate, but varies with the water temperature of the seasons; pupation is induced by the rise in temperature in the early summer that follows completion of larval development. Synchronization of emergence within the day is likewise brought about by rising temperature, and leads to a peak soon after solar noon. It has also been discovered that some chironomids, although the adult insect takes no food, can proceed to a second ovarian cycle and will in time lay a second, smaller batch of eggs.

Meteorological observations maintained at Hazen Camp for 5 years yielded two important conclusions that support the concept of a distinct high-arctic life zone. At this high latitude (81° N), the altitude of the sun remains above 10° throughout the 24 hr for more than 2 months in the middle part of the year. The steadiness of incoming solar energy leads to a similar steadiness of temperature through the day

and once the mean daily temperature has risen slightly above 32 F, "night" frosts are rare. The frost-free season is in fact longer at Hazen Camp than at any mid-arctic site for which records are available. Moreover, the solar altitude at 0.00 hr is sufficient, for a period of many weeks, to prevent the temperature at the surface of the soil from falling below the air temperature; a "nightly" inversion, customary at all lower latitudes, does not set in. The insects, therefore, resting at the surface of the soil or in the low vegetation, occupy at all times the warmest stratum of the environment.

Diversity in Insect Communities

72

The investigation of the diversity of the species present in sporophores of the fungus *Polyporus betulinus* Bull. ex Fr. has been greatly extended. Large samples were provided by the Department of Forestry and Rural Development from forests in New Brunswick that had been sprayed with DDT for 15 years, and others from unsprayed forests nearby. Additional large samples from "nonpolluted" areas were collected in Manitoba, Ontario, Quebec, and Newfoundland. The sporophores were then maintained in individual containers until the emergence of the insect fauna was completed, and a record of species and individuals from each sporophore was obtained. The analysis of this comparison of a significant part of the terrestrial fauna under natural and artificially modified conditions will soon be completed.

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8. Bright, D. E. 1967. A review of the genus *Cactopinus,* with description of two new species and a new genus (Coleoptera: Scolytidae). Can. Entomol. 99:917–925.
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Food Research Institute

Ottawa, Ontario

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Departures

F. W. Lee (Mrs.), M.Sc. Transferred to the Cell Biology Research Institute, Ottawa, September 1967	Plant physiology
E. W. Seitz, B.S.A., M.S., Ph.D. Resigned February 1967	Metabolism

VISITING SCIENTISTS

K. E. Eapen, Ph.D. National Research Council postdoctorate fellow 1967–68	Development of edible meal from rapeseed
V. L. N. Murty, B.Sc., M.Sc., Ph.D. Term appointment, September 11, 1967 to April 30, 1968	Physio-chemical studies of polysaccharides
S. N. Sengupta, B.Sc., M.Sc. Sponsored by External Aid Office 1967–68	Food technology training
W. Watanabe, Ph.D. National Research Council postdoctorate fellow 1967–68	Application of microwave energy to food processing

INTRODUCTION

During the past year, the program of the Food Research Institute has become more focused. We work on fewer projects and these projects either define a problem or are subdivisions of a problem. Differentiation of a problem into projects shows the need to employ more than one discipline in studies to solve food and agricultural problems. When the Institute or the Research Branch lacks required facilities, and these are available at a university, grants-in-aid of research are used to effect the multidisciplinary approach.

In the Institute, we feel that our knowledge of a subject is incomplete until we are able to write recommendations for the

benefit of animal or plant breeders, food processors, cold storage operators, and ultimately, the consumer. Communication among the food researcher, processor, and producer is essential if the maximum benefit is to be obtained from specific research findings. To this end, the Institute has engaged a Food Research Liaison Officer to obtain, disseminate, and apply new scientific knowledge within the Canadian food industry.

R. P. A. Sims
Director

CHEESE QUALITY

Cottage Cheese

Homogenization of skim milk improves significantly the quality of cottage cheese made with agglutinating starter cultures. Agglutinin titers of whey from unheated skim milk were reduced 50–75% by homogenization, whereas those from pasteurized skim milk were unchanged. The quality defects observed must therefore proceed through a more complicated mechanism than simple agglutination of starter bacteria.

Milk-clotting Enzymes

Rennet shortages have forced the cheese industry to consider other milk-clotting enzymes. A large-scale experiment to evaluate the effect of a 50:50 mixture of rennet and pepsin on the quality of aged cheddar cheese is under way. Six-month results show no important differences in quality between the experimental and control cheeses.

Milk Enzymes

The enzyme *β-N*-acetylglucosaminase has been found in bovine milk. The enzyme resembles catalase in its distribution among the subfractions of milk. The optimum pH for the hydrolysis of *p*-nitrophenyl-*β-N*-acetylglucosaminide is 4.2. The enzymic activity is inhibited by acetate ions, *N*-acetylglucosamine, heparin, and *p*-chloromercuribenzoate.

Cheddar Cheese Flavor

Volatile flavor components—It has now become evident that many of the volatile compounds present in Cheddar cheese have only a minor influence on flavor. This was shown by gas-chromatographic analysis of the volatile components from cheese made aseptically, with and without starter. The volatile components were similar, although cheese made without starter lacked the characteristic Cheddar flavor.

A new technique for trapping all the components eluted from the gas chromatograph showed that the collected sample did not have the characteristic Cheddar flavor of the injected sample. A reappraisal of column materials is under way.

Bitter flavor components—Acid pH (4.6) was found to be essential for the extraction of bitter components from Cheddar cheese. The bitterness of acid extracts was not affected by neutralization. An astringent-tasting fraction was separated from bitter extracts. Thin-layer chromatography and gel electrophoresis studies showed that the bitter and astringent fractions are different.

Catty flavor defect—The characteristic "catty" odor, which occurs sporadically in Cheddar cheese, has been duplicated by; (i) treating cheese surfaces with mesityl oxide and storage for 3 weeks; and (ii) reacting hydrogen sulfide with mesityl oxide. Mesityl oxide was identified as a component of defective cheese. Mass spectra of the reaction product from (ii) were consistent with the expected addition product, 2-mercapto-2-methyl pentan-4-one.

MICROBIOLOGY

Byssochlamys nivea

Byssochlamys nivea requires a heat shock at 75 C for 5 min and aeration at pH 4.0–4.5 for good germination of the ascospores. The effect of various cations was studied. EDTA affected spore germination, probably through alteration of membrane permeability. Cupric iron reduced germination and oxygen uptake significantly. A similar effect was noted with aluminum and ferrous ions but not with manganese ions. The effect of acetate in energy metabolism was shown by the use of C^{14}-labeled acetate. Heat-activated spores liberate carbon dioxide from acetate much more rapidly than dormant spores, which also utilize acetate.

Endopolygalacturonase and endopolymethylgalacturonase have been demonstrated in culture filtrates of *B. nivea.* Pectin methylesterase was found in trace amounts in some filtrates, but no evidence has been obtained for the presence of enzymes liberating terminal galacturonic acid, or pectin transeliminases.

Lactic Streptococci

Streptococcus diacetilactis 18-16 was shown to have a constitutive, NAD-dependent, L-malic dehydrogenase in the soluble protein fraction. Most of the label from malate-C^{14} appeared as lactate and CO_2. The main part of the label from glucose-C^{14} was found in the lactate fraction. In a medium containing 0.5% sodium L-malate the pH did not drop below 5.0, whereas in the absence of malate the pH reached 4.4. The cell yield was much higher in a buffered medium.

Dicarboxylic acids added to reconstituted skim milk at a 2% level increased the survival percentage of three strains of lactic streptococci held in frozen storage at −10 F. In neutralized cultures (pH 6.5) the order of efficiency was succinate, fumarate, malate, and citrate with a survival maximum of 80% after 38 weeks storage. Succinate was also quite effective without neutralization, 65% survival.

Starter cultures from cheese factories appear to be more resistant to bacteriophage attack than laboratory isolates from the same cultures. It has been postulated that an "interferon-like" resistance develops through contact with phage. Two single-strain cultures were carried for more than 50 transfers in milk containing 10% of heated homologous phage lysate whey. No increase in phage resistance was observed for either culture.

Cheese Microflora

Twenty Canadian Cheddar cheeses were examined for pediococci. Pediococci constituted about 1% of the nonstarter lactic flora; one cheese contained 8%. Their characteristics are consistent with the classification *Pediococcus cereviseae* Balcke.

POTATO QUALITY

Netted Gem potatoes from Western Canada generally produce better-textured frozen French fries than the same variety grown in the Maritimes. A multidisciplinary study of the physical and chemical properties of potato tubers from the two areas, and their relationship to the textural quality of frozen French fries has been organized. Potatoes from both areas were stored at the Institute under controlled conditions and withdrawn for testing at regular intervals.

Chemical Mapping of the Potato Tuber

Analysis of data has shown significant differences in the distribution of several constituents. Potassium and phosphorus contents increased from the stem to the bud end. The pith area was lower than the remainder of the tuber in Mn, Zn, Cu, and dry matter, and higher in Cl. There were indications of a decrease in dry matter and N from the stem to the bud end. Starch distribution followed this pat-

tern: low in the surface layer (1 mm) of the tuber; increased to a maximum in the next layer bounded internally by the vascular ring; decreased in each of the next two equal layers into which parenchyma was divided; and reached a minimum in the pith.

Low Molecular Weight Sugars in the Potato Tuber

Previously reported work has been concluded with the identification and characterization of the following components: milibiose, maltotriose, digalactosyl glycerol, glucosyl myoinositol, raffinose, planteose, galactinol, manninotriose, stachyose, and trigalactosyl glycerol. Five compounds were detected in small amounts; three disaccharides: ribosyl-glucose, xylosyl-glucose, and arabinosyl-glucose; and two trisaccharides: both made up of fructose and glucose units in the ratio of 2:1.

Effect of Storage on Amylose:Amylopectin Ratio of Potato Starch Granules

Starch granules obtained from eastern and western potatoes were classified into five groups according to the diameter. Determinations of the amylose:amylopectin ratio for each granule size group showed that: the amylose:amylopectin ratio is very slightly affected by storage over a 6-month period; and there was no practical difference in the amylose:amylopectin ratio between Alberta and New Brunswick potatoes.

Characterization of Potato Cell-wall Components

Preliminary work indicates that cold water soluble material contains, after acid hydrolysis, arabinose, glucose, galactose, and galacturonic acid. Analysis of the two main alcohol-soluble fractions obtained from water-soluble material shows that one contains glucose (dextrins) and the other galactose, arabinose, galacturonic acid, and traces of rhamnose.

The water-insoluble material was hydrolyzed by amyloglucosidase to yield soluble and insoluble fractions. Analysis of the soluble material after dialysis, freeze-drying, and acid hydrolysis showed the presence of xylose, arabinose, mannose, glucose, galactose, and galacturonic acid. The insoluble fraction contained xylose, arabinose, glucose, galactose, galacturonic acid, and traces of rhamnose.

Frozen French Fry Texture

The texture of frozen French fries, prepared by a standard process from the stored potatoes, was determined monthly. Results over the period December 1966 to June 1967 showed that western potatoes produced better-textured frozen French fries than eastern potatoes. Also, frozen French fry texture did not change significantly over this test period.

FOOD PROCESSING

Food Quality Research

Beef tenderness—Four high-finish carcasses and four low-finish carcasses were aged for 2, 9, and 16 days under commercial conditions. Cooked longissimus dorsi and semimembranosis muscles were evaluated by a taste panel and a modified Warner-Bratzler shear instrument. Statistical analysis of the experimental results showed that beef tenderness is affected by aging but not by finish.

Irradiation of peaches—The effect of irradiation doses of 150, 200, and 250 krads on the keeping quality of Veteran peaches stored at 38 F was studied. Microbial rot was significantly reduced by the three irradiation levels. Flavor, texture, and color characteristics were not adversely affected by the three dose levels. The acceptability of all the peaches, including controls, was poor after a 3-week storage at 38 F.

New Product and Process Development

Modification of French fry processing—Water-blanched potato strips were exposed to 2 kw of microwave energy and 280 F forced air, simultaneously, for 0 to 180 sec before deep fat frying. Texture of the finished French fry was not significantly improved, although weight loss from the potato strips ranged up to 19%.

French fries from cooked, mashed potatoes—A new process has been developed. It consists of a short cooking period, followed by French fry strip formation from the mash by cutting, rather than by extrusion. Sensory evaluations showed the experimental product to be equal to good commercial French fries in overall acceptance, although the flavor and texture characteristics were significantly different.

Cryogenic freezing—Preliminary studies into the effect of freezing rates on the quality of fruits and vegetables showed that liquid-nitrogen freezing improved the quality of strawberries, peaches, green beans, and corn. The application of liquid nitrogen must, however, be carefully controlled to avoid cracking and shattering effects. Definition of the optimum freezing rate for a wide variety of fruits and vegetables is the main objective of this research.

Microwave heating—A commercial microwave oven was modified to incorporate a variable-speed open-mesh conveyor and a forced-hot-air system for studying the continuous production of weiners. Weiners of acceptable quality have been made using the following conditions: exposure to 2 kw of 2,450 mc of microwave energy and 170 to 180 F forced air for 70 to 80 sec. Color and flavor characteristics were achieved by conventional methods—ascorbate and liquid smoke. The amount of microwave energy necessary to cook weiners has been determined.

Edible rapeseed meal—The use of rapeseed meal and protein for human consumption is being investigated. An acceptable moist-heat method for inactivating the enzyme myrosinase has been developed. It quickly inactivates the enzyme, and the extracted oil is of improved quality. Optimum conditions for the removal of thioglucosides and hulls from the meal are being determined.

FRUIT AND VEGETABLE STORAGE

Relationship Between Constituents of Apple Leaf and Fruit

The breeding of new apple varieties would be facilitated if fruit quality could be predicted through chemical analysis of seedling leaves. Chemical analysis of mature leaves and fruit has shown a high correlation between the total leaf and fruit phenols, the total leaf and fruit sugars, and the leaf free acids and fruit total phenols.

If these correlations hold between juvenile leaves and the later-borne fruit, undesirable seedlings can be discarded and it may be economically feasible to force the remaining seedlings into bearing in 3 to 4 years.

Polyphenols in McIntosh Apple Peel

A mild extraction and purification procedure for polyphenols has been developed. Anthocyanin pigments, proanthocyanin, quercetin glycosides, catechins, and chlorogenic acid were separated from each other after one- and two-dimensional paper chromatography. Cyandin-3-galactoside (idaein) and two other minor anthocyanin pigments were present. A polymeric proanthocyanin and at least three quercetin glycosides were also found in the peel fractions.

Arbutin in Pear Fruit

Arbutin and monoacetylarbutin may be implicated in the browning in pear fruit.

Arbutin was identified in this laboratory as a constituent of fruits from four commercial varieties of *Pyrus* by methods of paper chromatography. Arbutin was also isolated as a crystalline pentaacetate from immature pear fruit, in which it is present in the highest concentrations. Monoacetylarbutin, which accompanies arbutin in young pears, was tentatively identified on paper chromatograms at the same time.

Low-temperature Browning Disorders in Apples

In a continuation of studies linking low-temperature browning disorders with changes of the "growth-regulating complex" in cold-stored apples and their seeds, a number of polycyclic phenols have been examined for root-differentiating properties. Solutions of oxidized phloridzin, quercitrin, rutin, catechin, and chlorogenic acid all favored root initiation. The solutions of oxidized phloretin and quercetin were particularly effective. All solutions of oxidized phenols showed some chelating property. The addition of ferric ion caused "browning" in solutions of oxidized chlorogenic acid, catechin, quercitrin, quercetin, phloridzin, and rutin.

LIPIDS

Lipoproteins from Plant Sources

Preliminary studies showed that a good yield of lipoproteins can be obtained from plant tissue by homogenization and centrifugation. Lipoproteins with a lipid:protein ratio of 3.3 were isolated from rapeseed meal. Gas–liquid chromatographic (GLC) analysis of this extract showed the erucic (C22:1) and eicosenoic (C20:1) fatty acid content to be low and that of palmitic and linoleic high. This was explained when thin-layer chromatographic (TLC) analysis of the lipoproteins showed the phospholipid content to be considerably higher than the 31% found in the residual lipid of rapeseed meal. The fatty acid composition of various lipid extracts obtained from rapeseed has been determined.

Natural Antioxidants of Turnip Roots and Potato Tubers

The tissues of turnip roots and potato tubers were investigated by TLC and GLC techniques for the presence of tocopherols. Results obtained to date show that of the four known isomers of tocopherol only trace quantities are present in turnip roots and none in potato tubers.

PROTEINS

The Multiple Myoglobins of Beef Muscle

Experimentation with gel and buffer compositions for the large-scale (milligram quantities) polyacrylamide gel electrophoretic preparation of three myoglobin fractions has continued. To date, homogeneous collection of two of the three protein pigments is possible only by repeated electrophoretic runs.

The cyanometmyoglobin derivatives of the three proteins exhibit identical absorption spectra over the range 270 to 570 mμ.

Destruction of Methionine in Proteins

Methionine must be fed below normal levels to persons having the inborn metabolic disease homocysteinuria. The methionine content of casein was reduced from 2.7 to 0.8% within a few hours by reacting it with cyanogen bromide at room temperature. Animal feeding studies of the end product are in progress.

It was found during this work that cyanogen bromide reacts slowly with free tryptophan in acid pH to form colored compounds.

Honey Oligosaccharides

Previously reported work on the oligosaccharides of honey has been concluded. Highlights of this first attempt to resolve the oligosaccharide components of honey systematically and quantitatively are: the isolation and identification of two β-linked disaccharides, gentibiose and laminaribiose; discovery of two new trisaccharides 2-α-maltosyl-glucose and the linear 4-α-gentiobiosyl-glucose; expansion from 15 to 26 of the original list of the oligosaccharide constituents of honey. (White, J. W., Jr. 1963. The Hive and the Honey Bee, Dadant & Sons, Hamilton, Illinois, p. 369–406.)

Synthesis of Dimethyl Esters of D-Galactose

In 1960, Siddiqui and Adams described the isolation and characterization of 3,5-di-*O*-methyl-D-galactose from a methylated polysaccharide of *Gibberella fujikuroi.* This sugar has now been synthesized along with 2,5-di-*O*-methyl, 2,3-di-*O*-methyl- and 3-*O*-methyl-D-galactose.

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M. C. Coligado, B.S.A., M.S.	Agroclimatology

ARDA Climatological Contract 1967–68

J. Eriksson, Ph.D.	Mycology

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INTRODUCTION

This report gives a synoptic account of the research activities in the Plant Research Institute for 1967. Details are given in the publications listed at the end, and reprints of "in press" articles may be obtained by writing directly to the authors.

Our phytotron was completed in 1967. The prototype of the growth rooms was constructed in 1961, but modifications in design, budgets, and other obstacles caused the long delay. The present facilities are one of the most modern complexes for growing plants under controlled environment.

On April 1, 1967, the Plant Biochemistry, Frost Hardiness, Phytopathology, and Virology Sections were transferred to the new Cell Biology Research Institute. Among the 13 research scientists who were transferred were some of the most productive members of our Institute. A special note of appreciation is extended to them for their dedication to their tasks and their unswerving support.

The 48 research officers remaining in the Institute constitute a well-balanced team for research on plants and their environments—our primary objective.

Allan Chan
Director

AGROMETEOROLOGY

Weather and Crop Production

Estimation of potential evapotranspiration (6)—A previously developed technique for estimating daily potential evapotranspiration (PE) from standard climatic observations was improved by substituting in the regression equation the long-term averages of those climatic elements for which daily observations were not available. By comparing monthly values of the regression estimates of latent evaporation with monthly PE (in inches), estimated by means of Penman's formula, a conversion factor of 0.0034 was verified. A correlation coefficient of 0.92 for 267 monthly means from across Canada was found.

Estimation of soil moisture (6)—A computerized mathematical model for estimating daily soil moisture (SM) in various horizons of the soil profile from standard climatic data was used to calculate soil moisture distribution under a variety of soils, climates, and crops. At a number of sites across Canada, correlation coefficients between SM estimates and twice-monthly measurements under wheat over five seasons varied from 0.62 in the upper zones to 0.93 in the lower zones; a coefficient of 0.90 was obtained for the total SM in the whole soil profile.

Estimation of potential crop yields and crop yield components (4, 5)—Over a period of 5 years, at several sites across Canada, SM estimates were also related to wheat yields and wheat yield components from 39 plantings. Used alone in simple regression, SM accounted for 70% of the total variation in yield, maximum temperature for 49%, minimum temperature for 59%, but rainfall for only 17%. Thus, SM was a better estimator of crop yields than any other single climatic element. SM conditions from jointing to heading of wheat were very important and affected the number of heads, the number of kernels per head, the 1,000-kernel weight, and the total grain yield.

Crop Development and Weather

Biometeorological time scale—A mathematical model has been developed that relates rate of wheat development to photoperiod and to day and night temperatures. Allowance is made for upper and lower critical limits and the optimum value of each of the three environmental factors. Climatological and crop data from several CDA stations across Canada over 5 years were used in the evaluation. When estimates of the dates of phenological stages were compared with observed dates, the triquadratic model was superior to three other models. This was also true when a second independent set of data for Canada and a third set from Argentina were used in the statistical tests. Daily rates of progress towards maturity, calculated by means of the model, can be integrated to give a biometeorological time scale, which has practical applications in studies related to the effect of weather on crop production and farming operations.

Agroclimatology

Estimating agroclimatic normals (151)—A technique was developed for estimating monthly and annual long-term normals of temperature, growing degree-days, photothermal units, and freeze-free periods for any point on the Canadian Great Plains, using the latitude, longitude, and elevation of the location, and sets of coefficients developed by the National Research Council. The estimates have proved useful in connection with the evaluation of land capability.

Mathematical model to estimate site suitability (73)—A mathematical model of the multiple regression type based on seven climatic normals was developed to estimate relative site suitability indices for the winter survival of woody ornamentals at any locality in Canada. These normals are low winter temperatures, length of frost-free periods, high summer temperatures, summer and winter rainfall, snow depth, and wind speed. The multiple correlation coefficient obtained by this model was 0.98, and the coefficient of variation of estimated indices was 9.6% of the mean, which was 49.

Meteorology and the Canada Land Inventory

Land capabilities in Canada (3, 6)—The broad objective of the Canada Land Inventory is to obtain a firm estimate of the extent and location of all agriculturally settled lands, classified by their capabilities for agriculture, forestry, recreation, and wildlife. For proper interpretation, climatological data and analysis are necessary supplements to this inventory. The Agrometeorology Section has developed several techniques for using climatological data for such interpretations.

Data Processing Developments in Agrometeorological Research

Problems and development (148, 149, 151)—The introduction of magnetic tape systems has made necessary the transfer of climatological data files from cards to magnetic tape. Because of the inaccessibility of individual records on tape, the occurrences of missing data, sequence errors, multiple punches, and other unacceptable data are most critical. The experience gained in handling climatic data punched into cards was reported in a special bulletin. Many programs were developed for a specific use, but some of general interest were documented and described in detail.

Micrometeorology

Analysis of evaporation measurements (45, 46)—A study of the effect of various meteorological factors on evaporation from black porous disc atmometers provided an insight into the physical behavior of such instruments under field and controlled conditions. Data from evaporimeters were used to illustrate the effectiveness of combining multiple-regression technique with cross-spectrum analysis in agrometeorological time-series studies.

Frost protection by foam (47)—The effectiveness of protein-based foam as a protective insulation against frost damage was studied by analyzing the temperature distribution in the soil and within the foam during radiative and advective frost situations. Under certain conditions the foam-covered plants were 12 F warmer than unprotected plants.

ARBORETUM AND ORNAMENTALS RESEARCH

Arboretum

New trees and shrubs—Forty species of native shrubs in the nursery have developed sufficiently for evaluation of horticultural potential. Among these, *Aronia prunifolia* (Marsh.) Rehd., with its brilliant dark red foliage, has consistently provided the best fall color. A prostrate form of the vigorous *Salix lucida* Muhl., collected in the Gaspé, has maintained this habit in the nursery and shows promise for use as a ground cover. Numerous other native shrubs and vines are also showing promise for greater use as ground covers.

New *Sorbus* hybrids fruited for the first time during the year. Highly rated cultivars were Apricot Queen, Chamois Peach, Copper Glow, Coral Beauty, Pink Queen, Rose Elegance, and White Wax. All have highly colored fruits, good foliage color, and disease resistance. Among the shrubs, *Sorbocotoneaster pozdnjakovii* Pojark, an intergeneric hybrid, was the most interesting as its foliage combined the characteristics of both *Cotoneaster* and *Sorbus*.

Test Gardens

Evaluation of ornamental plants—During the year, 2,491 cultivars and seedlings of new ornamental plants were evaluated. These included woody plants; herbaceous perennials; bulbous, cormous, and tuberous plants; garden annuals and related plants; and outdoor chrysanthemums.

The two groups of annuals selected for intensive testing during the year were antirrhinums and zinnias. One hundred and forty-four antirrhinum and 106 zinnia strains and cultivars were evaluated. Also, 406 cultivars of new and undisseminated seedlings were rated.

A collection of 115 hybrids of *Phlox paniculata* L. from Europe, United States,

and Canada was evaluated. The following rated 80 points or more from a possible 100 points: Caroline Van Den Berg, July Glow, Annie Laurie, Dodo Hanbury-Forbes, Hampton Court, Joan, Olive Symons-Jeune, Mies Copijn, and Windsor.

Winterhardiness

Indices of woody ornamentals (72)—Determination of relative winter-hardiness indices of 174 species and cultivars constituted the first step towards the zonation of ornamental trees and shrubs for winter survival. Calculation was based on 8,325 items of hardiness data obtained from a survey of 108 stations across Canada. Actual site-suitability indices for winter survival for surveyed stations were based on hardiness indices of species surviving there.

Map of plant hardiness zones in Canada (74, 143, 144)—Suitability indices of about 640 localities were estimated and a map prepared. This map includes 10 zones (0 to 9) and each zone is subdivided into two subzones (a and b). A list of indicator trees and shrubs and the coldest zone in which they can survive is printed on the margin of the map.

Probable winter survival of woody ornamentals (74)—A method was developed to determine probable winter survival of ornamental trees and shrubs within the 10 suitability zones of the map. Probability curves were drawn to show plant hardiness and site suitability.

Methods of measuring winterhardiness—Highly significant correlations between the wheatstone bridge and the telemetry system of recording electric resistance readings (e.r.r.) of overwintering ornamental plants were established.

Studies also showed that the e.r.r. of plants could be used during winter to test the viability of outdoor plants. Both methods have confirmed that during winter the e.r.r. of injured tissues were significantly lower than the e.r.r. of similar living tissues. Thus, at a temperature of about 32 F, readings below 25,000 ohms indicated that tissues of roses were winter injured. Readings of healthy tissues of roses at the same temperature ranged from about 50,000 to 180,000 ohms depending on variety. The differences in e.r.r. are also useful for determining the probable time and cause of winter injury of outdoor plants.

Winter storage of nursery stock—After a natural outdoor hardening period from September 27 to November 14, 1966, balled and burlapped nursery stock of *Thuja occidentalis* L. 'Fastigiata', *Juniperus chinensis* L. 'Mountbatten', *Taxus cuspidata* Sieb. & Zucc., and *Buxus microphylla* Sieb. & Zucc. var. *koreana* Nakai overwintered successfully in a hardening room at 32 F ± 3 F. During this period there were 18 days with cold temperatures of 32 F to 20 F.

When plants in replicated lots were overwintered in a polyethylene greenhouse (one-half covered with black film to eliminate direct sunlight) at temperatures ranging from 18.6 F to 39.8 F, *T. occidentalis* and *T. cuspidata* exhibited considerable injury. Prestorage treatments such as short photoperiods and growth-inhibiting chemicals (CCC, B-9, and MH-30) did not consistently aid in winter storage of the nursery material.

Turfgrass

Soil compaction—Lawn mixtures established on a sandy loam soil were subjected to light and heavy seasonal compaction by a modified turf aerifier. Analyses of soil samples taken from the plots before and after treatment indicated that soil bulk density was increased by 6% and the total percentage of soil pore space was reduced by 6 to 12%. Compaction treatments severely restricted water percolation rates and lowered the total dry matter of plant roots in the 2- to 6-inch soil zone.

Turf species subjected to compaction can recover provided adequate fertility and moisture are available. Soil analyses also indicated that frost action helped to reduce compaction effects. Turf renovation by aeration and vertical slicing further aided recovery. Merion Kentucky bluegrass recovered more quickly and completely than did common Kentucky bluegrass, creeping red fescue, or perennial ryegrass.

Simulated flooding—In a greenhouse experiment, Merion bluegrass in pots was completely immersed in water or im-

mersed to only crown level, for multiples of 7 days up to 35 days. Conductivity of plant electrolytes and plant recovery were the indices of treatment effects. Merion recovered completely and quickly after 35 days in which the water level was above the plant crown but below the tips of the leaf blades. Plants completely immersed for 21 days released less than 50% electrolytes from the crown and roots and were fully recovered 1 month later. Plants completely submerged for 28 or 35 days released 90% of their electrolytes and required 3 months to recover from the treatment.

Floriculture

Chemical growth control—Experiments were conducted to determine the proper conditions and chemicals for disbudding of the various cultivars of chrysanthemums. A number of naphthalene derivatives were screened for activity as disbudding agents, based on the fact that heavy aromatic naphtha (HAN) compounds used to disbud chrysanthemums contain a large proportion of naphthalene derivatives. Compounds giving the most consistent positive results were 1-methylnaphthalene and alpha-naphthalene. Naphthalene derivatives substituted at the 2 position were relatively inactive as disbudding agents.

High light intensity and high CO_2 in atmosphere affects seedling growth—The rate of growth and development of ornamental plants beyond the seedling stage appears to depend greatly on the environment and conditions of growth immediately after germination. Experiments show that *Zinnia, Petunia,* and *Antirrhinum* grown to the seedling stage at high light intensity (3,000 ft-c) and high CO_2 content in the atmosphere (1,300 ppm) and subsequently returned to the greenhouse developed much faster than seedlings of the same age grown under standard greenhouse conditions. These experiments are continuing with several varieties of *Petunia, Antirrhinum, Coleus, Lobelia, Begonia, Delphinium,* and *Pelargonium.*

MYCOLOGY

National Mycological Herbarium

The current total holdings have increased to 160,864, an increase of 3,875. The general collection numbers 117,675, whereas the exsiccati and special collections total 43,189. The latter figure includes the 9,000-specimen private collection of Prof. L. E. Wehmeyer that contains many types and slides on which his work on Pyrenomycete taxonomy was based.

Identifications performed for various agencies were: Canada Department of Agriculture, 1,115; Department of Forestry and Rural Development, 218; Universities and other Research Institutes, 258; general public, 307.

Taxonomic Research

Phycomycetes—Olpidium cucurbitaceae-rum Barr, a new species parasitic on cucumber roots, has been recognized after morphological and physiological comparisons with *O. brassicae. Rhizophydium sphaerotheca* Zopf has been shown to be a species complex consisting of at least three critically distinct species and several physiologically distinct strains. *Hyphochytrium catenoides* Karling was isolated from soil from Lake Hazen in the High Arctic, from agricultural soils in Ontario, and from Arizona desert sand, and was found to decompose cellulose in vitro. Research has been started on *Lagena radicicola* Vanterpool & Ledingham, a parasite of wheat.

Ascomycetes—Pyrenomycetes (1, 43, 44, 51, 87, 88)—*Cucurbitaria piceae* Borthwick, *Camarosporium strobilinum* Bomm., Rouss. & Sacc., and *Megalosep-toria mirabilis* Naumov, parasites of spruce buds, were redescribed and *Megalospora gemmicida* Naumov was found to be the same as *C. piceae. Paraphaeosphaeria michotii* (West.) O. Eriks. was found in Canada for the second time since 1889 when it was described as *Leptosphaeria folliculata* Ell. & Ev.

Research was completed on the taxonomy of two fungi from wheat roots: *Pseudostemphylium chlamydosporum* Hoes, Bruehl & Shaw and *Dendryphium penicillatum* (Corda) Fr. and its perfect state *Pleospora papaveracea* (De Not.) Sacc. Laminate structure of the inner wall of the bitunicate ascus of *Botryosphaeria* and *Pleospora* species was demonstrated.

A taxonomic revision of the genera of the Hypodermataceae of the world was completed. Seven of the 22 genera treated were new. *Davisomycella fragilis* Darker, a new species of the Hypodermataceae that causes a needle blight of *Pinus banksiana* Lamb. in northern Ontario, was described. Studies continued on the Hypodermataceae and certain fungi responsible for their biological control, on the Hysteriales in Canada and New Zealand, and on miscellaneous new or rare fungi.

Diaporthe alleghaniensis R. H. Arnold, a new species, and its *Phomopsis* state were described and shown to cause a disease of *Betula alleghaniensis* Britt. Inoculations over several seasons showed that the fungus can cause a canker and foliage disease of vigorously growing yellow birch seedlings and saplings, but subsequent development of the disease depended on environmental conditions. The fungus may be present in the host without symptoms and may persist in pathogenic form in healed-over wounds for several years. There was some evidence that the fungus produced a wilt-inducing agent. Germination of conidia was stimulated by injured birch tissue.

Ascocarp development and cytological studies are well under way on *Wallrothiella subiculosa* von Höhn., *Aithalomyces rhododendri* Woron., and *Metacapnodium juniperi* (Phill. & Plowr.) Speg. (a comparative developmental study), and *Amphisphaeria incrustans* Ell. & Ev., *Leptosphaerulina australis* McAlpine, *Balansia epichloe* (Weese) Diehl, and *Xylosphaera iantho-velutina* (Mont.) Dennis. A manuscript on the ontogeny of *Platyspora pentamera* (Karst.) Wehm. is nearly completed. The development of a fungus parasitic on *Carex* florets was elaborated and mature ascocarps were obtained for the first time. This fungus, previously known as *Hyalodothis caricis* Pat. & Har., will be described as a new species and disposed in a new genus of the family Dothideaceae.

Ascomycetes—Discomycetes—Morphological, taxonomic, and life history studies are being carried on with inoperculate Discomycetes of the family Dermateaceae. Genera under intensive study at present include *Ascocalyx, Encoeliopsis, Pezicula,* and *Phibalis.*

Species of *Ciboria* produce apothecia on stromatized fruits or catkins of their hosts in most provinces in Canada. Seven of the nine species collected have been grown in culture, and five of these produced apothecia. A taxonomic account of the nine species based on natural collections and in vitro studies is nearing completion.

Basidiomycetes—rusts and smuts (75, 81)—A group of papers dealing with fungi that parasitize Scrophulariaceae was completed. One has been published and the remaining three have been submitted for publication. These papers deal with 38 species, including 50 subspecies and varieties. Five new species, six new subspecies, and seven varieties were described, and five species were recorded as new for North America. These papers illuminate interrelationships of some host genera and the method of coevolution of hosts and parasites.

A monograph of the autoecious species of *Puccinia* on Heliantheae in North America was completed. In the monograph 62 taxa including six new species and six new varieties were recognized, but the subspecific division of the wide-ranging *P. helianthi* was not accepted.

Basidiomycetes—Hymenomycetes—In a continuing study of species of *Rigidoporus* Murr., 90 isolates were described according to standard methods, and growth temperature curves were determined. The curves were consistent for the isolates in each of nine species, but two types of curves were obtained for the isolates under *Polyporus giganteus* Pers. ex Fr. and those under *Poria sanguinolenta* (Alb. & Schw. ex Fr.) Cooke, which indicates that two species have been confused under each of these names. Descriptions of cultures and fruit bodies of 13 species of *Rigidoporus* are being prepared for publication. Four isolates from

collections identified as *Papulospora* sp. have hyphae with clamp connections, characteristic of species of Hymenomycetes, and they produce fruit bodies that have been determined as *Sistotrema* sp. Interfertility tests have shown that the species is heterothallic and tetrapolar.

New isolations were made of about 24 species, with several new or unexpected results. Two species of *Pellicularia* were found to be capable of forcible discharge of basidiospores. Both species were cultured and one produced an *Oidium* state not previously reported. *Tubulicrinis calothrix* (Pat.) Donk was isolated, although members of this genus have rarely been cultured. *Gloeocystidiellum porosum* (Berk. & Curt.) Donk was cultivated and produced mature fruit bodies in culture. *Tremella mycetophila* Peck was cultured from basidiospores and proved to be only a tumorous outgrowth of the mushroom, *Collybia dryophila* (Bull. ex Fr.) Kummer.

Long-term studies on pairing between monokaryons derived from 31 collections from North America and Europe were reported (64). Lack of compatibility in 1,772 intracollection pairings coupled with morphological differences of typical sporophores, growth in culture, and host specialization form the basis for the conclusion that the poroid, irpicoid, and lamellate forms are three separate species, *Hirschioporus abietinus* (Dicks. ex Fr.) Donk, *H. fusco-violaceous* (Ehrenb. ex Fr.) Donk, and *H. laricinus* (Karst.) Teramoto.

Fungi Imperfecti (62, 63)—Current studies relate European and North American species to recent collections of 28 species of *Sporidesmium* Link ex Fr. and of four species of *Conoplea* Pers. ex. Fr. from New Zealand; at least 12 new species are involved. In collaboration with Prof. W. B. Kendrick and Mr. G. T. Cole, a monograph of *Phialophora* Medlar is being prepared that covers about 15 species isolated from wood and wood products in North America. *Metacapnodium juniperi* (Phill. & Plowr.) Speg. was collected in the type locality, and will be redescribed in detail as part of a study of this genus of sooty molds. Work was completed with Dr. C. H. Dickinson on four species of *Gliomastix* Guéguen, including one new species, and with Professor W. B. Kendrick on 16 species in the genera *Menispora* Pers., *Codinaea* Mare, and *Menisporopsis* Hughes, including 14 new species.

Conidiophore structure and conidium formation in the Hyphomycetes *Doratomyces stemonites* (Pers. ex Fr.) Morton & Smith and *Helminthosporium oligosporum* (Corda) Hughes are being studied with the aid of an electron microscope.

Arctic fungus flora—Parasitic fungi and host plant specimens were collected in central Baffin Island during July and August. Host specimens have been deposited in the phanerogamic herbarium, and fungus specimens are being studied.

PLANT GROWTH AND DEVELOPMENT

Morphogenesis

The phytomer concept in grasses—In the grasses and cereals, initiation of new vegetative organs is not a continuous process; it occurs in stages, each separated from the previous stage by a period of apparent inactivity. A new stage is initiated by lateral cell divisions in the base of the dome that encircles the apical meristem. This zone gives rise to a leaf, the stem internode in part, the axillary bud, the adventitious root primordia, and the greater part of the node. Collectively, these organs, formed from a single foliar primordium, are termed a phytomer. The basic premise of the phytomer concept is that the axillary bud is of the same biological age and origin as the leaf above, rather than the leaf in whose axil the bud is found.

In the mature regions of the plant, the distinction between phytomers becomes confusing. The node delimits the upper extremity of one phytomer and the lower extremity of the next. Anatomically, a phytomer has an extremely complicated system of vascular interconnections and

is very poorly understood. However, a newly developed vital staining technique using vacuum infiltration has allowed individual leaf veins to be traced to their point of attachment in the main vascular systems of the stem. The main leaf veins do not form vascular connections within the node they enter, but traverse the full length of the internode below and connect with the vascular system at the next lower node. The vascular system of the bud connects with the veins of its own phytomer leaf above. The peculiarities of translocation from the leaf to the stem and buds can be resolved on the basis of the phytomer concept.

Biochemistry

Plant growth regulators—The degradation of indole-3-acetic acid (IAA) in plants, cell-free extracts, or enzyme preparations was studied intensively previously and several mechanisms were suggested. Of these, the mechanism involving free radicals in the degradation of IAA gained prominence. This involvement of free radicals during the enzymic or nonenzymic degradation of IAA was demonstrated using the stable free radical, 2,2-diphenyl-1-picrylhydrazyl.

A new class of plant growth regulators called morphactins, derivatives of fluorene-9-carboxylic acid, may be of interest as herbicides, plant growth regulators, and inhibitors of senescence in detached plant parts. The effect of these compounds on geo- and photo-tropisms of plants is of particular interest as a novel and basic phenomenon. A chromatographic method for the separation and identification of some fluorene-9-carboxylic acid (morphactin) derivatives was developed.

Plant Growth

Growth efficiency of wheat—The rate of growth of a plant was classically considered to be the product of a rate constant called the "relative growth rate" and its dry weight. Experiments have not supported such a conclusion because the relative growth rate usually changes during growth. However, constancy of the relative growth rate has now been obtained over the first 4 weeks of growth of Marquis wheat plants by reducing self-shading of leaves of plants grown in controlled-environment rooms. The numerical value of the relative growth rate depends on the plants and environmental conditions used in the experiment. The value will approach a maximum as optimal growth conditions are reached. The rate of photosynthesis was found to be a hyperbolic function of light intensity which made possible the calculation of maximum rates of growth. Since the calculated maximum rates were three times the rates obtained under the high artificial light intensity presently used for plant growth, there is considerable potential for further increases in the relative growth rate under these conditions.

Growing plants in controlled environments—The optimum temperatures for germination and emergence in Went's medium were determined for several crop plants: 25 C for oats, beans, peas, wheat, and rape; 30 C for barley, tomatoes, and cucumbers; and 35 C for corn. The same optimal germination temperatures were obtained in darkness, and in 16 hours of light.

The optimum light and dark temperatures for the early vegetative growth of crop plants were established under 12-hour photoperiod. The optimum light temperatures were 25 C for wheat and peas and 30 C for cucumbers, corn, beans, tomatoes, and oats. The optimum dark temperatures were 20 C for peas, 25 C for oats and wheat, and 30 C for cucumbers, corn, beans, and tomatoes.

It was previously reported that a blue–red–far-red fluorescent lamp, gro-lux WS, gave as good plant growth in a controlled environment as cool-white fluorescent supplemented with incandescent lamps. A combination of half gro-lux and half gro-lux WS fluorescent lamps was tested and the dry weight accumulation after 6 weeks' growth was slightly less than under gro-lux WS lamps alone. The span of time to head emergence of oats and wheat was delayed 2 and 7 days respectively by the combination of lamps, and periods of flowering of beans and tomatoes were not affected. Therefore, no advantage resulted from the use of this combination of lamps for these plants.

Greenhouse supplementary lighting—Gro-lux wide-spectrum fluorescent, cool-

white fluorescent, and iodine–quartz incandescent lamps were compared for greenhouse lighting. Control plants were grown under natural daylight. The iodine–quartz lamps were inferior to the fluorescent lamps for increasing plant growth. After 6 weeks, growth of tomatoes and beans was 30% higher under gro-lux WS than that under cool-white, but the growth of wheat and oats was the same under the two types of fluorescent lamps. Head emergence of wheat and oats was hastened 13 days by gro-lux WS but only 2 to 5 days by cool-white. All these types of lights hastened flowering of tomatoes and beans by only 2 to 4 days.

TAXONOMY OF THE VASCULAR PLANTS

Herbarium, Index Seminum, and Plant Identification

Herbarium (120)—The vascular plant collection contains 548,583 mounted specimens, a growth of 14,044 during the past year. Loans of 2,691 specimens were made to 23 cooperating institutions.

Index Seminum (119)—The Institute continues to offer seed of many native and adventive plants to other research centers through Index Seminum. Some 7,154 packets of seed were sent to 338 institutions during the year. In return, approximately 9,400 packets of seed were received from 243 institutions for research scientists in the Department, the National Research Council, various Canadian universities, and other agencies.

Plant identification—During the year, approximately 2,500 plants were identified in the taxonomy section. This service was performed for the general public and for other scientific and governmental agencies in Canada.

Floristic Studies

Flora of the continental Northwest Territories (38)—This cooperative project with the National Museum is well advanced. A checklist of the plant taxa will be available early in 1968. Field work was carried out in the Mackenzie Mountains during the summer of 1967, and a large number of specimens were collected.

Enumeration of the plants of Canada (21–28)—The publication of this list consisting of eight parts has been completed. An index will be published shortly. The enumeration provides pertinent bibliography of family and generic monographs, distribution according to province and territory, and a list of 5,433 taxa occurring spontaneously in Canada. Special listings are included for Greenland, Alaska, and St. Pierre and Miquelon.

Flora of the Prairie Provinces (33, 34, 35)—This flora, started nearly 20 years ago, has been completed. These papers will be brought together in a group of four memoirs.

Flora of the Queen Charlotte Islands (37, 91)—The first two volumes have been completed and will be published early in 1968. These two volumes contain a detailed systematic and phytogeographic as well as a cytological review of nearly 600 taxa.

Flora of Gatineau Park—A preliminary field study has been completed. This project will serve as a pilot study to determine the feasibility of producing floras for the major parks in Canada.

Local floristic studies (40, 69, 127–130)—The publication of a floristic inventory of Mont Ste. Marie, north of Ottawa, and studies on the occurrence of some rare plants in the Ottawa district were completed.

Flora North America project—During the past year, the Plant Research Institute was active in the planning and development of the proposed cooperative American–Canadian project to produce a concise and diagnostic manual of all vascular plants in North America north of the Mexican – United States border.

Polygalaceae of Canada—A systematic review of the family has been completed and will be published in the Research Monograph Series of the Department of Agriculture.

Tamarisks in United States and Canada (13)—A review of the introduced and naturalized species was completed.

Major Taxonomic Studies

Leguminosae (55)—The systematic study of the genus *Trifolium* was continued. The chromosome numbers of 28 species have been reported. A study of the *Trifolium longipes* Nutt. polyploid complex is well advanced. A comprehensive study of the chromosomal and morphological variation in the large genus *Dalea* is continuing in cooperation with the New York Botanical Garden.

Cruciferae (68)—The last paper in a series on the cytotaxonomy of the genus *Physaria* was completed during 1967. Ten species are recognized for this western North American genus. Morphology, chromosome numbers, and karyotypes were described, and the meiotic behavior of interspecific and intraspecific hybrids were given. The reevaluation of the genus *Physaria* resulted in the transfer of three species to *Lesquerella.*

Linaceae (66)—Evolutionary studies on wild North American species of flax (*Linum*) continued with a field trip to Mexico to collect seed and specimens for hybridization experiments and for studies of speciation mechanisms.

Saxifragaceae—Work continued on the preparation of the systematic treatment of the Saxifragaceae for Canada and Alaska. A detailed study of pollen morphology in the family was initiated utilizing electron microscopy.

Gramineae (16)—A study was initiated to elucidate the systematics and taxonomy of the genus *Avena.* It is proposed that the research will result in a worldwide monograph of the genus. During the summer of 1967 over 5,000 oat cultivars were grown to determine possible ancestry through use of micromorphological characters. A survey of introduced wild oats and of cultivated oats growing spontaneously in Canada is near completion. The delimitation of the genus *Avena* and its generic relationships has been established.

A manuscript on wild-rice has been completed and will be published next year. This publication will provide a detailed study of habitat requirements, geographical distribution, evaluation of the taxonomy, and a review of the economic potentialities of the plant as a food crop.

Plantaginaceae (9, 11)—A taxonomic review of the family has been continued. This review has been completed for three sections of the genus and includes chromosome numbers, palynology, distribution, and taxonomy of the taxa. Detailed studies of the pollen morphology have been reported for 28 species of *Plantago* and one species of *Littorella.* These studies were combined with an examination of the floral and reproductive biology.

A monograph of the plantains of Canada and Alaska is in preparation.

Compositae (65)—A study of the foliose thistles (*Cirsium*) for western North America was published. The distribution, morphology, cytology, and taxonomic problems of the 12 species of *Cirsium* native to Canada has been described in a series of papers. Preparation of a book on the seven genera of the tribe *Cardueae* found in Canada is advanced.

Chenopodiaceae—A preliminary survey of the genus *Atriplex* included a field trip to Western Canada. Several species new to the flora of Canada were found and a reevaluation of the chromosome numbers found in the genus has been undertaken.

Weeds—A revision of Weeds of Canada was begun during the year. Nearly 20 taxa with illustrations were added, and information accumulated during the past 12 years has been incorporated in the text. The revised manuscript will go to the printers in 1968.

Air-borne Pollen Surveys

10, 97

Air-borne pollen counts have been completed for 17 stations in British Columbia. The results of this study have been published. The 1967 revised edition of Canadian Havens from Hay Fever contains the most recent ragweed-pollen air indices from across Canada, and represents the results from 207 stations.

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Soil Classification and Genesis

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J. H. Day, B.S.A., M.S.A.	Soil classification and correlation
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Departures

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M. D. Webber, B.S.A., M.Sc., Ph.D. 1966–67	Chemical reactions in soils involving phosphate

INTRODUCTION

This report covers the main research activities and findings in the Soil Research Institute in 1967.

The Soil Research Institute at Ottawa is concerned mainly with basic and applied chemical, physical, and biological studies designed to give a better understanding of the nature and behavior of Canadian soils. This information is of great assistance in determining the cause of many problems associated with the different soils and in developing satisfactory solutions.

The Institute has assumed responsibility for the correlation of soils across Canada in order to facilitate their classification and the development of a national picture of Canadian soil resources. It cooperates with provincial institutions in soil survey programs in Nova Scotia, Ontario, and Alberta. The Cartography Section prepares and publishes all basic soil maps as well as soil capability and computer input maps in connection with the National Land Inventory sponsored by ARDA.

P. C. Stobbe
Director

SOIL FERTILITY

Potassium

Experiments on plant recovery of fixed potassium in soils were continued. Plants recovered added K from soils much more effectively than was expected from results of chemical extraction. Four soils, which fixed 69 to 93% of the added K against extraction with 1 N neutral ammonium acetate, released only 8% of the fixed K in four successive extractions with 0.5 N NaCl and only 14% in the leachate of 12 liters of 0.01 N HCl. In a pot test, however, nine successive crops of oats were estimated to recover 48% of the

added K. When the work was extended to one soil in the field, 93% of the added K was fixed following summerfallow for 1 year, and three cereal crops grown subsequently were estimated to recover 10% of the added K (750 lb of K_2O per acre). On the K-treated plots the increase in K uptake over the controls amounted to 21% of the total K uptake by the crops.

Phosphorus

Continuing studies on the constitution and significance of organic soil P have shown that 24 to 53% of the total organic P was present in inositol form in samples of Chernozem, Brown Podzolic, and Podzol soils. Much of the extracted organic P (about 80%) was present as the penta- and hexa-phosphate esters of inositol in the Podzol and its textural fractions, whereas these forms comprised only about 30% in the Chernozem samples. On the other hand, the latter contained more of the lower phosphate esters of inositol than the Podzol samples did. Gas and paper chromatography showed that other organic P compounds, as yet unidentified, were associated with the lower esters. Gas chromatographic analysis showed also that the inositol components isolated from the soils and textural fractions were comprised of four isomers of inositol—*neo, dl, seyllo,* and *myo.*

Organo-Metal-P Complexes

When a 1:1 Fe to fulvic acid molar ratio was used in the preparation, the fulvo-phosphate contained 39.1% C, 1.1% P, and 12.5% Fe, and 60% of the material was soluble in water. Elution curves (Sephadex gel filtration) showed that 75% of the material consisted of fulvo-phosphate, and the rest consisted of a mixture of fulvo-ferric complex and unbonded phosphate. These curves along with electrophoretic mobility measurements indicated further that the phosphate anion was instrumental in building up high molecular weight fulvo-phosphates. These compounds were not much better than inorganic iron phosphates as a source of P for growing corn plants, but they released large amounts of Fe to the plants.

Strontium-90

13

Although current work is concerned more with Cs^{137} than with Sr^{90}, materials available from earlier experiments offered an opportunity to assess the possibility of using contaminated soil for seed production. In an experiment where heavily contaminated seed of four crops (oats, barley, wheat, and soybean) were grown on uncontaminated soil, only a small amount of the radioactivity was found in the straw, and none was found in the seed. The soybean was examined further by taking a radioautograph, and it was found that most of the radioactivity remained in the cotyledons, although slight amounts were found in the hypocotyl. Radioactivity could not be detected in the epicotyl. It was concluded that it would be possible to use contaminated soil for the production of seed with reasonable certainty that second-generation seed grown on inactive soil would be free from Sr^{90}.

Soil Temperature

Studies on effects of soil environment on nutrient uptake by plants were continued, and some attention was given to metals, particularly Fe. Removal of Fe by oats from sandy soils was found to be related generally to the amount of growth as influenced by the temperature of the soil, particularly at the lower soil temperatures (10 to 20 C). The concentration of Fe in the plants was maintained at a higher level by reducing the night air temperature from 25 to 10 C on both the warm and cool soils (27 and 10 C). Thus crops grown on soils low in available Fe might be better supplied with Fe when the temperature during the evenings decreased than when it remained constant. When iron (Fe^{59}) was added to the soil, proportionally less was taken up by the crop as the temperature of the soil was raised.

Soil Management

28

Experiments on use of fertilizers were continued in the field, and certain aspects of soil–plant relationships were studied in pot tests. Restricted growth of oats, bar-

ley, and alfalfa, grown in pots using soil contaminated with excessive magnesium lime dust from an adjacent industrial plant, was associated with low Ca:Mg ratios in the plants. Further work showed that gypsum (5,000 ppm) and S (465 ppm) in combination were effective amendments for oats and gave a threefold increase in yield. The Ca:Mg ratio increased from 0.27 in the plants grown in the contaminated soil to 0.68 in those grown in the amended soil. The soil pH decreased from 8.6 in the contaminated sample to 8.1 in the sample receiving the amendment. Gypsum and sulfur together were more effective than either alone.

PHYSICAL CHEMISTRY

Reactions Between Aluminum and Clays

54, 55, 56, 57, 58

Studies of the reactions between Al and clays, and of the effect of the products of these reactions on the properties of the clays and the activity of $Al(OH)_3$ in the solution at equilibrium with the solid phases, have been continued. It has been shown that conditions under which the reactions occur play an important role in determining the nature of the products. If the reactions between an Al salt and a base proceed in the presence of clay, solid-phase materials with composition $Al(OH)_x$, with x less than 3, are precipitated on the surfaces of the clay, the residual positive charges of the precipitate being satisfied by charges of the clay. On the other hand, if the clay is added after the Al salts have reacted with the base, a polynuclear hydroxyaluminum cation complex is formed, and is adsorbed by the clay in the exchangeable form. The precipitated material reduces the cation exchange capacity (CEC) of the clay, but the polynuclear cations do not.

Reactions of Sulfate in Aluminum–Clay Systems

49, 50

Studies of the reactions between SO_4, Al, Ca, and OH ions in the presence of clays have been continued. When $Al_2(SO_4)_3$ was partly neutralized by $Ca(OH)_2$ in the presence of Wyoming bentonite, an amorphous precipitate was formed and this precipitate was present as an interlayering material. The composition of the amorphous precipitate was $Al(OH)_{3-2x}(SO_4)_x$. Over prolonged periods, the crystalline phase of basic aluminum sulfate was formed and the interlayering material disappeared.

The amorphous precipitate reduced the exchange capacity only by 6 to 11 meq/100 g of the Wyoming bentonite. There was no inactivation of exchange capacity when the crystalline basic aluminum sulfate was formed. The time required to form the crystalline basic aluminum sulfate depended on the initial OH:Al ratio and the amount of Al precipitated per unit weight of clay. The ion product $(Al)(OH)^3$ of the equilibrium system was $10^{-33.6\pm0.1}$ when the crystalline phase was formed.

Cation Exchange in Soils

7, 8

Studies of the cation exchange properties of the soils of Vancouver Island, B.C., showed that in general the soils had high base saturation even though the precipitation was high. The pH-dependent CEC values of the soils were highly correlated with organic matter and oxalate-extractable Al. Complexes of Al with organic matter appeared to be the main source of the pH-dependent CEC in the soils.

Soils with fragipans from the drier southeastern part of the Island had corrected lime potential values in the upper part of the profile that were as low as, or lower than, those for soils from the more humid and more densely forested parts of

the Island. The upper solum of soils with fragipans was enriched with oxalate-extractable Al but not with free Fe oxides.

For soils of pH less than about 5.4, the determination of CEC at pH 7, before and after oxidation with H_2O_2, provided a simple means of estimating the amount of organic pH-dependent CEC. This technique provided a useful indication of sesquioxide – organic matter complexes accumulated in medium- and fine-textured soils.

MINERALOGY

Alteration of Clay Minerals in Soils

5

The clay minerals in the Ae horizons of Podzols were distinctly different from those in the Ae horizons of Gray Brown Podzolic and Gray Wooded soils. Trioctahedral chlorites were completely decomposed in Podzols, whereas they persisted in the other soils. The expanding-layer clay minerals in the Podzols showed no impedance to collapse upon heating, whereas in the other soils there were indications of varying amounts of interlayer hydrous Al and Fe oxides. Furthermore, in the Podzols, there was a marked difference in the clay mineralogy of the Ae and B horizons, whereas in the other soils there was a gradual decrease in the degree of alteration of the clay minerals with depth in the profile.

Within a group of Podzol Ae clay fractions there was a variation in the kind and amount of mica alteration, which appeared to be related to the degree of podzolization. This was found from a study of the nature of the interstratified mixtures of the three components mica, montmorillonite, and vermiculite. The proportion of hydrated-layer minerals, montmorillonite and vermiculite, and the degree of randomness of stacking of the layers was related to the TiO_2 content.

Experimental Alteration of Clay Minerals

25, 40, 45, 50, 56, 57

Continued studies of the kinetics and mechanism of decomposition of chlorites in acid solutions disclosed that the reaction proceeded from the circumference of the disk-shaped particles inwards and that the reacted layer formed a diffusion barrier. It was also established that Al, Fe, and Mg were removed from the various octahedral and tetrahedral lattice positions at the same rate.

The interlamellar adsorption of fulvic acid was found to be affected by the cation with which the clay is saturated as well as by the pH and fulvic acid concentration in solution.

The nature of the aluminum hydroxide precipitated from chloride or sulfate solutions in the presence of montmorillonite was determined by the effect of relative humidity and successive heat treatments on the structure.

Mineralogy and Structure Analysis

1, 14, 15, 23, 24, 41

A series of trioctahedral brittle mica specimens were shown to be similar crystal-chemically and it was proposed that this mica end-member species be named clintonite.

SOIL BIOCHEMISTRY

Effect of Organic Amendments on Soil Nitrogen

The laboratory work on the effect of 20 annual additions of different organic amendments to a sand and a clay soil was largely completed in 1967 and reports on changes in the C and N status and on the productivity of the treated soils have been prepared for publication. On the check plots and those to which green rye was added there was a decrease in both C and N over the 20-year period. The other amendments, straw, leaves, alfalfa, manure, peat, and muck, at least main-

tained the C and N levels and in some cases increased them, the effect being somewhat greater in the sandy soil. The muck gave the largest increase in C and N and the peat had the greatest effect on the C:N ratio. Nearly all the changes occurred in the first 10 years. In spite of the fact that the treatments affected the C and N contents and the C:N ratios, they had little effect on the N distribution or on the amino acid composition. There was no correlation between any of the forms of nitrogen—acid soluble-N, ammonia-N, amino acid, and amino sugar-N—and yield. But in the clay, all the amendments except green rye increased yield, and, in the sand, alfalfa and manure gave yield increases. In general the amendments increased nitrate production and exchange capacity and the manure increased the P content.

Effect of Freezing on Biological Activity in Soil

22

Studies showed that exposing a soil to freezing increased the amount of extractable water-soluble amino acids. Further work demonstrated that freezing and thawing also brings about an increase in water-soluble sugars. In addition Warburg Respirometer studies showed that freezing increases soil respiration by 20%, indicating that microbial substrates are being released by the action of frost. A relationship was observed between dehydrogenase activity and soil respiration after freezing and thawing of soil.

Polyphenols in Sphagnum

In connection with a study of the phenolic composition of organic soils, analyses of the plants that form peat were undertaken. One of the significant findings was that the general composition of the phenolic acids in sphagnum did not differ appreciably from that found in the organic soils. In particular, ferulic acid, which is a prominent phenolic compound found in cultivated organic soils, was detected in sphagnum.

Biological Applications of Differential Thermal Analysis

The methodology, some recent experimental data, the advantages as well as the limitation, and the potential uses of differential thermal analysis in biological research will be discussed in one of the treatises on protein chemistry scheduled for publication by Academic Press in 1968.

HUMIC ACID CHEMISTRY

Chemical Structure of a Podzol Fulvic Acid

20, 21, 24, 42, 44, 45, 48

Previous studies at the Institute had shown that fulvic acid extracted from a Podzol Bh horizon is a highly oxidized, biologically stable humic compound that can complex di- and tri-valent metal ions and hydroxylated metal compounds and can interact with clay minerals. In addition, fulvic acid can also exert more direct effects by entering the plant and influencing plant metabolism. Since fulvic acid is known to occur in all soils, additional work on its chemical structure appeared to be warranted.

To prepare molecularly homogeneous fractions, the fractionation of fulvic acid on Sephadex gel of different sizes was investigated. Six fractions were prepared; most of the material had a relatively low molecular weight. Each fraction was characterized by ultimate and functional group analyses and by infrared, ultraviolet, visible, and n.m.r. spectroscopy. In addition, the molecular weight of each fraction was determined by vapor-pressure osmometry. It was concluded that all fractions were made up of essentially similar chemical structures.

Earlier structural work on fulvic acid had indicated that this material consisted primarily of isolated aromatic rings heavily substituted with oxygen-containing functional groups and that the aromatic rings were linked to each other by aliphatic chains, saturated cyclic or hydroaromatic structures. To obtain additional information on the chemical structure of fulvic

acid, two lines of investigation were undertaken: (i) dehydrogenation with Se, and (ii) Zn-dust distillation. Although both methods gave small yields of a large variety of products, Zn-dust distillation appeared to be the more promising approach. By a combination of procedures such as high-vacuum distillation, and thin-layer and gas chromatography, it has been possible to separate a number of aromatic ring structures of differing degrees of condensation. More definitive identification of individual compounds is now under way. The most interesting finding so far is that for each unit weight of material, the Zn-dust distillation of humic acid yields almost 10 times as many polycondensed aromatic ring systems as does that of fulvic acid.

Biological Degradation of Fulvic Acid

Studies aimed at isolating products of biological degradation of fulvic acids were continued. *Poria subacida* Peck, the organism in use, proved to be of limited value because of the presence of phenol oxidases, and because the activity of the particulate fraction of its cell-free preparation was restricted to reduction of the carboxyl groups.

The approach was therefore widened to include chernozemic humic acids and several, some newly isolated, fungi and bacteria. Since phenol oxidases might transform products, only those organisms not possessing these enzymes, and those that were capable of producing more CO_2 from the fulvic or humic acids than can be accounted for by mere decarboxylation, were studied further under various cultural conditions. However, all procedures attempted so far for recovering degradation products have proved inadequate. Another approach is now being investigated. Attempts are being made to break complexes of the degradation products and residual humic compounds by chemical means such as methylation.

SOIL PHYSICS

Moisture Movement

52

Emphasis was on two main topics: (i) developing sensitive equipment for measuring moisture contents, potentials, and conductivities without disturbing the soil; and (ii) improving methods for using conductivity data to predict moisture profiles during infiltration and redistribution.

Gamma-ray equipment and pressure transducers were assembled to give a continuous record of water content, pressure potential, and potential gradient as water flowed through soil columns in the laboratory. The recorded data were used to compute accurate conductivity and diffusivity coefficients at different moisture contents as the soil was alternately wetted and dried. Preliminary measurements with Uplands loamy sand and Castor sandy loam showed that further improvements in techniques for filling and packing the soil columns were required.

The gamma-ray equipment is now being used in basic studies in the theory of hysteresis as applied to actual soil. Heretofore such work has been restricted to idealized porous material such as glass beads.

Comparisons of computed and measured moisture profiles during moisture redistribution after infiltration showed that the conductivity data used for the lower half of the available moisture range were not accurate enough to predict moisture changes over long periods. Subsequently a method was developed whereby values of conductivity and diffusivity at low moisture contents were deduced from drying potential scanning curves and measured redistribution profiles. The method shows promise in providing conductivity data at moisture contents at which direct measurement is difficult. Independent tests of the conductivities derived from data at one initial infiltration depth are being made by checking computed values with moisture distributions obtained at other initial infiltration depths.

SOIL CLASSIFICATION AND GENESIS

Studies of Canadian soil resources have been continued in cooperation with provincial organizations in Nova Scotia, Ontario, and Alberta. Soil correlation studies have been carried out in all provinces in connection with soil classification and the preparation of interpretive soil capability maps. Particular emphasis has been placed on interprovincial and international correlation studies in connection with the compilation of a soil map of Canada and of North America and with the characterization and classification of organic soils. Research on chemical and physical characteristics significant to the identification, classification, and genetic interpretation of soils has been continued.

Nova Scotia—Nova Scotia Agricultural College, Truro

Field and laboratory studies of the soil in Cumberland County have been continued and about 320,000 acres were covered. A detailed survey of the Musquodoboit River watershed was started and about 17,000 acres were mapped. Field and laboratory data on the soils of Annapolis County have been interpreted and compiled for publication.

Ontario—University of Guelph

The detailed study of the soils of Brant County, including a study of the relationship between landform and the genesis and morphology of soils on lacustrine materials, has been continued. Reconnaissance soil surveys of Peterborough County and of the Fort William and Iroquois Falls districts of Northern Ontario have been continued. Over 3.3 million acres comprising most of the settled areas of Northern Ontario have been covered and soil and land capability maps for these areas are being prepared.

Alberta—University of Alberta, Edmonton

Reconnaissance soil surveys were continued and approximately 1.21 million acres were mapped and classified on the following map sheets: Tawatinan, N ½ 82-I (1 million acres); Wainwright, 73-D (160,000 acres); and Fernie and Kanaskis, 83-G and 83-J (50,000 acres). A special study of soil characteristics and their relationship to the terrain was started in the North Saskatchewan drainage basin within the Rocky Mountain region. The compilation of the interpretive soil capability maps was continued. Further studies were carried out on the climate and its limitations to soil capability for agriculture.

Soil Genesis

30, 31, 32, 33

Investigations of the microstructure and composition of B horizons of varied Canadian soil types have been continued as an aid to their genetic interpretation and to their characterization and classification. In thin ironpans of Humic Podzols from Newfoundland the cementing materials consisted mainly of an iron-saturated fulvic acid complex. In Acid Brown Forest soils, in which the A and B horizons are often not distinct, the humic to fulvic acid ratios were generally greater than 1 in the A and less than 1 in the B horizons. Micromorphological studies indicated that some of the soils formerly classed as Textural Podzol should be classified as Gray Wooded soils.

Correlation and Classification

Extensive correlation studies of Canadian soils have been carried out on an interprovincial level. A critical study of a wide range of organic soils by Canadian and American soil scientists has resulted in suggestions of improved criteria for the identification and classification of these soils. These improved criteria will be recommended for adoption by the two national organizations in their respective classification systems.

Further correlation studies and discussions have been conducted with American and Mexican soil scientists in order to

bring about closer integration in the classification of soils and in the definitions of soil units for a soil map of North America, which is being compiled. This is part of an FAO–UNESCO project for a soil map of the world.

CARTOGRAPHY

During the year, the Cartography Section prepared and published 49 basic soil and soil capability maps. It also prepared a large number of computer input maps for the various sectors of the Canada Land Inventory of ARDA.

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Administration

P. S. Corbet,[1] B.Sc., Ph.D., D.Sc., F.I.Biol.	Director
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J. A. Walsh,[2] B.A., B.L.S.	Librarian

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C. D. Dondale, B.Sc., M.Sc., Ph.D.	Spiders; population analyses
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B. M. Hegdekar,[1] B.Sc., M.Sc., Ph.D.	Biochemistry and physiology
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C. C. Loan, B.A., M.Sc., Ph.D.	Parasites
M. G. Maw, B.Sc., B.Sc., M.Sc.	Atmospheric electricity

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[2] Seconded from Departmental Library.
[3] On educational leave.

L. G. Monteith, B.S.A., M.S.A.	Apple maggot ecology
D. P. Peschken, B.S.A., M.Sc., Dr. Sci. Agr.	Biological control of Canada thistle
D. F. Riordan	Physical sterilants
P. Singh,[4] B.Sc., Assoc. I.A.R.I., Ph.D.	Behavior and nutrition
B. C. Smith, B.A.	Food ecology
H. G. Wylie, B.A., D. Phil.	Host–parasite populations

Departures

J. S. Barlow,[5] B.S.A., M.A., Ph.D.	Biochemistry
B. P. Beirne,[5] B.Sc., M.A., M.Sc., Ph.D., M.R.I.A.	Director
P. Belton,[5] B.Sc., A.R.C.S.	Physical controls
Thelma Finlayson (Mrs.),[5] B.A.	Parasite larvae
A. R. Graham,[6] B.S.A., M.Sc.	Nutrition
J. P. M. Mackauer,[5] Dr.Phil.nat.	Aphid parasites
K. K. Nair,[5] B.Sc., M.Sc., Ph.D.	Chemical sterilants
A. L. Turnbull,[5] B.S.F., M.S.F., D.Phil.	Population analyses
J. M. Webster,[5] B.Sc., Ph.D.	Entomophilic nematodes

VISITING SCIENTISTS

E. F. Boller, Ing.Agr., Dr.Sc.Tech. National Research Council postdoctorate fellowship, 1966–67	Population dynamics of fruit flies
A. Mansingh, B.Sc., M.Sc., Ph.D. Sponsored by U.S. Army Natick Laboratories, 1966–67	Nutritional control of pests in processed foods
A. I. Mohyuddin, B.Sc., M.Sc., Ph.D. Graduate student, Queen's University, 1964–67	Biological control of weeds

INTRODUCTION

This report presents the main findings of research at the Research Institute, Belleville, Ont., during 1967. It is the fifth report, and the second annual report, to be published from the Institute.

The Institute's broad research objective is to discover how a pest's environment can be manipulated, by selective control, to reduce pest damage. Research is directed specifically to show how pests, or appropriate models of pests, interact with their physical and biotic environment. Emphasis is on the biotic environment, which includes the pathogens, parasites, predators, and competitors of a pest, as well as members of its own species. Particular attention is given to the processes that affect natural mortality or recruitment and to their role in population regulation. In the future, additional emphasis will be on factors affecting recruitment, notably mating behavior and fecundity.

In addition to its research function, the Institute also provides a service as the national center for information on biological control agents, and for their import and export. It supplies information and material to the Department of Agriculture and

[4] Appointed in August 1967.
[5] Resigned in 1967.
[6] Retired in August 1967.

the Department of Forestry and Rural Development, and provides liaison with the Commonwealth Institute of Biological Control to sponsor surveys and research needed by these departments in foreign countries.

This report follows the general plan of previous reports. Numbers beneath subheadings refer to publications listed at the end of the text. The full scientific name and, where applicable, the common name of each species of animal or plant mentioned in the report are given in the last section of the text, immediately before the list of publications. Names of the research staff have not been listed under formal subject categories because, as projects develop, some individuals move from one group to another, or perhaps participate in two groups at one time. Work groups are solely discussion and planning groups, subject-oriented and temporary in membership, that meet under the chairmanship of the most appropriate group leader.

Because many topical problems require an interdisciplinary approach, research cooperation is encouraged, both among individuals in the Institute, and between Institute staff and members of other establishments of the Department, other government departments, and universities. Close academic contact is maintained with the Department of Biology, Queen's University, Kingston, and the Department of Zoology, University of Guelph.

In 1967 four research staff were appointed, one retired, and eight left to establish a pestology center at Simon Fraser University, Burnaby, B.C. The previous Director, Dr. B. P. Beirne, was among the latter. As he was at the Institute until August 1, this report deals largely with work carried out under his direction.

Philip S. Corbet
Director

PHYSICAL FACTORS

Control of Aquatic Stages of Mosquitoes

Capric (decanoic) acid appears to be an effective mosquito larvicide. Although mortality rates varied with age, all larvae and most pupae died within 4 days when exposed to 0.002 M solutions of the acid made into its potassium soap. The soap was used to distribute the capric acid through the water, but field trials showed that it was not needed to kill the larvae. Capric acid placed on the surface of pools, in cakes or in small pieces in amounts equal to 0.002 M solutions, killed all the mosquitoes, though more slowly by several days than when soap solutions were used. Pools treated with capric acid attracted more oviposition by later generations than did nontreated pools; and no subsequent mortality attributable to the treatment was noted.

Trapping Mosquitoes

7, 8

Effectiveness of light traps—Argon and fluorescent ultraviolet lamps attract more mosquitoes and culicoides midges than do incandescent lamps with the same input power. A 40-w black-light fluorescent lamp is the most economical source. For both insect groups ultraviolet lamps are more attractive than incandescent ones.

Comparison of sound and light traps—Numbers of male *Aedes stimulans* caught in the two kinds of trap were of the same magnitude, but seemed to vary inversely: nightly changes in the light-trap catch followed changes in air temperature at dusk, whereas those in the sound-trap catches followed changes in relative humidity.

Oviposition of Mosquitoes

6

When the temperature of one of a pair of similar artificial pools was raised by about 6 C, the number of egg rafts laid there by *Culex restuans* increased threefold.

Sterilization of Mosquitoes

Work on the sterilization of *Aedes aegypti* by ultraviolet light was continued. Adults were irradiated with ultraviolet light (2,537 A) at ~ 3,000–3,600 $\mu w/cm^2$ from a 4-w fluorescent tube for $\frac{1}{2}$ to 8 min. In males this caused negligible immediate mortality, but reduced survival by 28%; progeny from survivors, mated individually with untreated females, were reduced by 96%. Tests with treated and untreated males confirmed that this reduction was caused by treated males failing to transfer sperm. Among females, mortality was negligible over the whole range; 2-min exposure reduced blood feeding by 55% and progeny by 88%.

Electrophysiology of Insect Muscle

In a joint project with the Research Institute, London, Ont., the electrophysiology of visceral muscle fibers in *Periplaneta americana* was investigated. They differ strikingly from the skeletal muscle fibers studied previously in this and other insects.

Effects of Air Ions on Plant Growth

40

Further analysis of work reported earlier showed that the increase in growth of *Lepidium sativum* observed when this plant is exposed to air ions of positive or negative polarity was greatest between new moon and the first quarter, and also during winter.

PARASITES

Research concerned parasites and hyperparasites of insect pests, and was directed towards several aspects of taxonomy, ecology, and behavior.

Taxonomy

20, 21

Parasites of the forest moths, *Acrobasis* spp., in the Ottawa, Ont., region were distinguished using characters of the larval skin left by the parasite in the host case from which it emerges. The cephalic structures, spiracles, and skins of the final-instar larvae of 30 species were described and illustrated, and a key was devised for their separation. A list was compiled of all known species of *Acrobasis* parasitized by the species concerned.

Work continued on final-instar larvae of the Porizontinae (Ichneumonidae) using the cephalic structures and spiracles as diagnostic characters. All of the 75 species examined and illustrated can now be identified in this way. Generic boundaries proved difficult to determine and have not yet been established.

The final-instar larvae of the eight hymenopterous parasites of *Acyrthosiphon pisum* in Eastern Canada were described and illustrated, and a key for their separation was devised.

Parasites of Aphids

36, 37, 38, 39

Research on the bionomics of hymenopterous parasites of *Acyrthosiphon pisum* was continued.

Development of the parasite *Aphidius smithi* and its hyperparasite *Lygocerus* sp. was followed, and the durations of the several stages, egg, four larval instars, and pupa, were recorded. Emergence of adults occurred 11–12 and 14–15 days, respectively, after oviposition.

The *Lygocerus* female places its eggs in either of two distinct regions of the host mummy. About 80% of the eggs are laid into the fifth to seventh abdominal segments of the mummy, a region corresponding more or less with the head–tail portion of the *Aphidius* larva; most of these eggs are laid close to the head region. The remaining 20% of the *Lygocerus* eggs are placed near the center of the *Aphidius* larva. Neither the sex nor the developmental time of the *Lygocerus* progeny is correlated with the oviposition site.

Parasites of Mirids and Flea Beetles

33, 34, 35

The number of mirid species known to be parasitized by *Leiophron* spp. (Braconidae) in the Belleville district was in-

creased to 41; 13 species of *Leiophron* were described as new and reviewed with other Nearctic material.

In *Leiophron pallipes* two temporally discrete, reproductively isolated populations existed in distinct ecosystems. These populations differed taxonomically and ecologically. The one present in early summer attacked mirids of 12 species and 5 genera on grasses and legumes; the one in late summer attacked two species and one genus on weeds. Life cycles of the parasites were synchronized with those of their hosts by an imaginal diapause. The second generation of the plant bug, *Adelphocoris lineolatus,* developed between populations of *L. pallipes,* and so was not parasitized.

Two undescribed species of *Microctonus* were reared from *Psylliodes punctulatus,* and one from *Longitarsus melanurus.* With each of these flea-beetle hosts, tylenchid nematodes were associates of the immature braconid parasites.

Parasite–Host Population Interactions

45

Laboratory experiments were continued to elucidate the competitive interrelationships of several hymenopterous parasites attacking a single host.

Females of *Nasonia vitripennis* usually discriminate between unparasitized house fly pupae and those that they have attacked previously, and they lay on the latter only after they have failed for some time to find unparasitized pupae. In contrast, females of *Muscidifurax raptor* discriminate in this manner only if the parasitized hosts have been attacked repeatedly. Each species oviposits readily on hosts attacked by the other, or by females of *Spalangia cameroni.* Several larvae of *N. vitripennis,* or only one of either of the other parasite species, can mature on each superparasitized host. On multiparasitized hosts only one species usually survives: *M. raptor* almost always when competing with *S. cameroni,* and usually when competing with *N. vitripennis;* and *N. vitripennis* when competing with *S. cameroni.* The effect on the outcome of competition among these three parasite species of the intrinsic superiority of *M. raptor* larvae is partly balanced by a higher oviposition rate for *N. vitripennis* and by a longer adult life-span for *S. cameroni.*

Host-selection Behavior

1

The ichneumonid, *Itoplectis conquisitor,* can be conditioned to attack tubes (containing host insects) of a nonpreferred color. Retention of this conditioned response was found to be unaffected by length of exposure to empty tubes.

PREDATORS

Work on predation is also reported in the sections devoted to insect–plant relations and population analyses.

Predation by Ants

4, 5

Predation on tent caterpillars—First- and second-instar larvae of *Malacosoma americanum* are acceptable as prey to many native ant species. Predation is correlated with ambient temperature. During a warm period early in spring ants forage actively and may completely destroy caterpillar nests; by contrast, a cool spring allows the caterpillars to develop beyond the vulnerable stage before ants prey on them.

Foraging behavior and prey density—In the laboratory, ants adjusted their foraging behavior to prey density. *Myrmica americana* consistently captured 50% of prey at prey densities of ½ to 32/ft² of forage area. *Formica obscuripes* showed a similar pattern at prey densities of up to 16/ft².

Predators of Mosquito Larvae

30, 41

Beetles—Eighteen species of Dytiscidae and two species of predaceous Hydrophilidae were found in vernal, woodland pools inhabited by *Aedes* spp. During mid-June beetles averaged 4.7–5.6/yd² in small pools to 2.7 in a large one. They were

more active at night than during the day and nearer the pool margin than elsewhere. Predators that breed in vernal pools follow an annual pattern related to the development of the mosquitoes. Some adult beetles come out of hibernation earlier than others; and the larvae of *Agabus erichsoni* and *Colymbetes sculptilis* complete development much sooner than those of *Acilius semisulcatus, Dytiscus fasciventris,* and *Hydrochara obtusatus.* Several species move to permanent waters shortly before vernal pools become dry, but they return to breed there in spring. Keys and descriptions are being prepared for larvae of Dytiscidae that inhabit semipermanent pools in Ontario.

Fishes—The mudminnow, *Umbra limi,* offers promise as a mosquito predator in higher latitudes and semipermanent pools —places where better-known control species have little value. In laboratory tests, high rates of predation on larvae and pupae were recorded.

PATHOGENS AND ENTOMOPHILIC NEMATODES

Diseases of Tent Caterpillars

Several strains of *Clostridium brevifaciens* and *C. malacosomae,* which are culturally fastidious, highly specific, bacterial pathogens of the tent caterpillar, *Malacosoma americanum,* have been maintained as vegetative cultures for 1–5 years. None of the bacteria infected first- or second-instar larvae of *M. americanum* when fed in high doses; yet spores isolated from diseased larvae and stored in concentrated aqueous suspensions at 3 C for 5–12 years were still highly infective. Several strains of both bacteria were reisolated in pure vegetative culture from diseased insects that had been fed old spores; these newly isolated cultures produced typical disease when fed to larvae in instars III–V, even after the fourth subculture, although continued subculturing decreases virulence. Modifying the culture medium failed to induce sporulation. Neither spores nor newly isolated cultures infected cutworm larvae of any instars.

Of about 50 nests of *M. americanum* collected near Belleville, Ont., in 1967, only one showed any signs of a natural virus infection.

Parasites of Black Flies

A survey of the Moira River, near Belleville, for nematode and protozoan parasites of black fly larvae revealed about four species of Mermithidae (including *Gastromermis viridis* and a *Mesomermis* sp.) and at least three microsporidians in eight common species of black fly. *Prosimulium fuscum* and *Cnephia mutata* were commonest during April, and *P. fuscum* was frequently parasitized by two mermithids, one of which (*Mesomermis* sp.) occurred often. During May *C. dacotensis* and *Simulium venustum,* the commonest species, were parasitized by different species of mermithid. Incidence of mermithid infection was not correlated with stream size or larval substrate. Species of *Thelohania, Nosema,* and *Caudospora* were found in the hemocoel and fat bodies of larvae.

Environment and Parasite Uptake

Larvae of aquatic insects are often infected by parasites when they feed; to investigate this process further the effect of environmental factors on larval feeding and parasite uptake was studied experimentally. Rate of filter-feeding in a black fly larva, *Simulium venustum,* at different temperatures was estimated by counting the charcoal particles it removed from an aqueous suspension of known concentration. Feeding rate increased with temperature and linearly with time. A single larva ingested an estimated 0.57 ml of water at 20 C, and 0.01 ml at 2 C in 80 min. When nematode larvae were in suspension, 50% more were ingested at 20 C than at 2 C, and more penetrated the gut wall into the hemocoel at 15 C than at 25 or 2 C. Mosquito larvae of *Culiseta inornata* in instar III ingested more charcoal particles and nematodes at 25 C than at other temperatures. First-instar larvae could not ingest the nematodes.

Improved Methods for Applying DD136

Widespread use of the nematode–bacterium complex, DD136, as a biological insecticide is partly restricted by the susceptibility of the nematode, *Neoaplectana* sp., to desiccation after it has been sprayed in aqueous suspension onto crop foliage. Therefore substances were tested that, when added to the DD136 spray, would retain the water film on foliage longer and consequently would increase the nematode's potential infectivity. When Gelgard M was added to water and sprayed onto foliage (0.13% w/v), more water adhered to the foliage. This water layer dried more slowly when Folicote 351 (0.2%) was added to the spray mixture, and it adhered better when Arlatone T (0.1%) was added. This nonphytotoxic, nonnematicidal mixture did not change the feeding habits of the insects. On insect-infested foliage sprayed in the laboratory with the Gelgard, Arlatone, and Folicote mixture (GAF) the nematodes lived longer and insect mortality increased. Four species of insect pest were exposed in the laboratory to DD136 sprayed in three different aqueous mixtures: water, Gelgard, and GAF. The mortalities for these three treatments were: *Pieris rapae*, 25, 100, and 100%; *Pristiphora erichsonii*, 24, 66, and 77%; *Leptinotarsa decemlineata*, 0, 73, and 80%; and *Euxoa messoria*, 0, 100, and 100%.

Encapsulation of DD136

As found previously for the sawfly, *Pristiphora erichsonii*, and for some species of *Aedes* and *Culex* mosquitoes, the beetle, *Leptinotarsa decemlineata*, showed partial resistance to DD136 by encapsulating some of the nematodes that entered the hemocoel. In *L. decemlineata* a colorless gelatinous capsule, which generally contains a few melanized particles, develops from host blood cells within 48 hr after exposure to the nematode.

NUTRITION

Food Selection and Nutrition

26, 28

When exposed to different synthetic diets, larvae of the sarcophagid fly, *Pseudosarcophaga affinis*, detected nutritionally defective foods and chose diets on which they grew most rapidly.

Many dry foodstuffs are self-protected to varying extents from attack by the flour beetle, *Tribolium confusum*, presumably owing to nutritional factors. This suggests that to package such foods according to their susceptibility rating would be economical.

Capric Acid as an Insecticide in Dried Foods

27

Because capric acid, a contact insecticide, is apparently harmless when ingested by higher mammals, it can be blended into certain foodstuffs to protect them against serious infestation. When added to whole wheat flour and dried brewer's yeast to constitute at least 2.5%, capric acid killed all *T. confusum* within 8 weeks. This uncommon use of an insecticidal fatty acid offers promise for controlling stored-product insects.

Cherry Fruit Fly Investigations

Culture techniques for the cherry fruit fly, *Rhagoletis cerasi*, were improved by devising better diets and light conditions, and an artificial oviposition device, which was needed for further studies on nutrition and chemosterilization of this pest. Tests of some 50 larval diets provided a guide for future improvements.

Administered orally to adults in the water source, the chemosterilants Tepa,[6] Apholate,[7] and Hempa[8] were effective.

[6] Chemirad Corp.
[7] Supplied by the Squibb Institute for Medical Research.
[8] Eastman Chemical Products.

Fatty-acid Composition of Parasites and Hosts

Among five species of sawfly examined (*Pikonema alaskensis, Neodiprion lecontei, N. sertifer, Pristiphora erichsonii,* and *P. geniculata*) only one, *P. geniculata,* had a high concentration of palmitoleic acid, a characteristic of Diptera though not of other insect orders. As its food plant, mountain-ash, does not contain a high level of this acid, it may be that *P. geniculata* differs metabolically from other sawflies. A possibly related fact is that the insect parasites of *P. geniculata* are all Diptera, whereas other sawflies have parasites from several orders. Therefore, pending corresponding studies on hymenopterous parasites, a causal relationship may be tentatively proposed between the "dipterous" fatty-acid composition of *P. geniculata* and the fact that it has only dipterous parasites.

Fat Metabolism of a Parasite on Different Hosts

9

Larvae of the ichneumonid, *Exeristes comstockii,* reared on different hosts showed that this parasite duplicates the fatty-acid composition of its host. The larvae achieve this by changing synthesis rates in direct relation to the concentration of fats in the host, and by incorporating directly fatty acids for which they have no synthesis pathways.

REPRODUCTIVE PHYSIOLOGY

Fecundity of a Parasite on Different Diets

Fecundity of adult *Exeristes comstockii* fed chemical diets in which the salt mixture was varied was not significantly changed when Mn^{++} or Ca^{++} were omitted, or when Zn^{++} was added. Complete omission of salt mixture reduced fecundity by a third, and substitution of Na^{+} for K^{+} in the salt mixture reduced eggs laid by 80%.

Recovery of fecundity of the same parasite given host larvae after a period of protein starvation was initially slower than in unstarved controls, but was eventually as complete. Amino acids fed at levels similar to that found in honeydew during the starvation period did not improve the recovery rate.

Hormonal Control of Ovary Development

11

In newly emerged females of *Exeristes comstockii* fed 0.1% farnesyl methyl ether (a chemical mimic of juvenile hormone) in sucrose, the number of eggs completing maturation was eight times that in females fed sucrose only. This shows that the metabolic reserve in newly emerged *E. comstockii* is substantially greater than was previously recognized and that, under certain circumstances, it can be made available for ovarian maturation.

Histology of Pheromone-producing Glands

In a cooperative project with the New York State Agricultural Experiment Station, Geneva, N.Y., techniques were developed for examining the structure of glands that produce the sex pheromone in females of certain tortricid moths. Whole mounts and sections of glands showed structural differences among 11 species belonging to two subfamilies, Tortricinae and Olethreutinae. These findings complement the studies at Geneva on the specificity of the male response to extracts from the different species.

INSECT–PLANT RELATIONS

Biological Control of Weeds

22, 50

Attempts to control noxious weeds by liberating, after screening, weed-feeding insects from abroad continued.

Hypericum perforatum—In British Columbia acceptable control has been achieved by two beetles: *Chrysolina hyperici* in the douglas-fir zone, and *C. quadrigemina* in the ponderosa-pine zone.

In grass-covered areas of the Kettle Valley neither was effective, but *Anaitis plagiata,* a moth released in 1967, showed promise.

Senecio jacobaea—The moth, *Hypocrita jacobaeae,* has increased annually since release in 1963 in Nova Scotia and in 1964 in British Columbia, and is weakly established in Prince Edward Island.

Linaria vulgaris—The moth, *Calophasia lunula,* has survived for 2 years at Belleville, Ont. Attempts to establish it in Western Canada continue.

Euphorbia esula and E. cyparissias—Larval mortality prevented establishment of the moth, *Celerio euphorbiae,* in most parts of Canada, except possibly at Braeside, Ont. The mortality was attributed to predation by ants.

Cirsium arvense—A new colony of the beetle, *Altica carduorum,* was released at Summerland, B.C. Colonies released in 1964 and 1966 in Ridgetown, Ont., and Welsford, N.S., died. At Halloway, Ont., at least two species of mite were responsible for the almost total mortality of the eggs, and *A. carduorum* survived only inside a field cage. At Lacombe, Alta., unidentified agents, probably predators, killed about 28% of the eggs and at least 69% of the young larvae. Tests with the gall-forming trypetid, *Urophora cardui,* showed that side-shoot development by the thistle could offset the damage caused by galls; so this fly may not be effective enough to justify its release. New colonies of the weevil, *Ceutorhynchus litura,* were released in Ontario, and larval and adult feeding as well as oviposition were observed. No specimens of *C. litura* liberated at Read, Ont., in 1966 were recovered.

Other weeds—Surveys for insects on *Ambrosia artemisiifolia* were made to obtain insects for exchange with the USSR, and to explore biocontrol possibilities in Canada. Host ranges were determined for insects on bindweed, *Convolvulus* spp., and a feeding stimulant was isolated from one of them.

POPULATION ANALYSES

Projects reported in this section are all long-term in nature. They were started in previous years and have not yet been completed. They include field and laboratory investigations.

Polyphagous Predators in Grassland

18

A long-term study of the role of spiders in regulating an arthropod community in grassland was continued.

Sample data for 1966, comprising arthropods sorted to family and spiders sorted to species (both were counted and weighed), were examined. Analyses of variance for numbers of meadow-dwelling leafhoppers gave standard errors for spatial blocks and days of 5–31% at intervals throughout the summer, when five randomly chosen 0.5 m^2 vacuum samples were taken daily on each block. Variability was similar to this in thrips, crickets, grasshoppers, spiders, and spittlebugs, and much greater in other groups. Raw data fitted the negative-binomial distribution.

The mark–release technique proved practicable for tracing movements of hunting spiders in a meadow. Pitfall traps were set in concentric circles (diam 50 and 100 ft) around a release point. When making releases from this central point care was taken to liberate spiders individually to minimize interaction between them. Recovery of 325 marked *Schizocosa avida* was 33%, of 155 *Schizocosa* sp. (undescribed) 31%, and of 166 *Arctosa emertoni* 34%. Of the recaptured individuals 83–90% of the males and 59–67% of the females were taken within 5 days of release. Average recovery of 310 individuals representing six other species of wolf spiders was 5.5%. Crab spiders were apparently less mobile: of 243 marked *Xysticus gulosus* only 10% were recovered, and of 156 individuals of seven other species only 8.8% were recovered. During

the investigation some individual spiders were recaptured repeatedly at different sites.

Laboratory studies on mating behavior, fecundity, and hibernation of wolf spiders continued.

Mortality of the Apple Maggot

Pupae of the apple maggot, *Rhagoletis pomonella,* suffered high mortality in unsprayed orchards. Puparia, formed by larvae obtained in the laboratory from fruit collected in a test orchard, were buried in the orchard at depths at which most apple maggots hibernate. Cumulative mortality among these test pupae was 50% by the time that frost would have stopped predation in the fall; 67% by apple-blossom time (full bloom); and 79% by the time of the first adult emergence. Among potential predators, crickets were the most numerous; and some were in the soil when the fall samples were taken. In the laboratory, crickets readily detected, unearthed, and ate puparia, even though a plentiful supply of acceptable food plants was available.

Movements of European Skipper Larvae

2, 3

Available control strategies for the skipper, *Thymelicus lineola,* are most effective when larvae move least. It is suspected that movement of larvae is density-dependent, and accordingly studies are planned on their dispersal. A preliminary field trial, in which 800 *T. lineola* larvae were marked with P^{32} and released where food was plentiful, showed that this technique can be used effectively for such studies. It was found that under these conditions larvae moved very little.

Natural Enemies of Alfalfa Pests

Work continued on the role of natural enemies in the control of the mite, *Tetranychus urticae,* on alfalfa. In the field, populations were sampled weekly at 90 points within a 75-ft square plot for the third consecutive year. Natural enemies included the mite, *Typhlodromus fallacis,* the plant bug, *Orius tristicolor,* coccinellids, thrips, and crickets. In the laboratory, food requirements and preferences of *T. fallacis* were partly determined, and *O. tristicolor* and crickets were shown to feed on *T. urticae.* In greenhouse experiments, *T. fallacis* limited populations of *T. urticae* at 72 F; *O. tristicolor* did not breed well on alfalfa infested with *T. urticae* and aphids; and crickets were ineffectual against *T. urticae* because they did not remain on the alfalfa.

Stored-product Pests

Development of a biological model for use in the study of interactions in a stored-product community continued. Such work necessitates the continuous culture of interacting species for long periods, over many generations, while fluctuations in numbers are monitored by regular sampling. Populations of the beetle, *Oryzaephilus surinamensis,* and its bethylid parasite were maintained for 80 weeks before they were destroyed accidentally by excessively high temperature. Comparable studies have been undertaken with the grain mite, *Acarus siro,* and two of its predators. A population of the mite and *Blattisocius dentriticus* was reared and sampled for 96 weeks, and populations of the mite and *Cheyletus eruditus* have been maintained for up to 30 weeks.

Ecology of Aphids and Their Coccinellid Predators

In June the aphid, *Acyrthosiphon pisum,* was the dominant species in a community studied on alfalfa. Its numbers comprised 89% and its biomass up to 80% of totals for all arthropods found with it on alfalfa. The alfalfa tolerated high populations of *A. pisum* without apparent damage. Warm weather was more favorable for reproduction of the aphids than for reproduction of their coccinellid predators.

High populations of the corn leaf aphid, *Rhopalosiphum maidis,* reduced ear weight of field corn by 38%. Occurrence of this aphid and corn pollen in favorable weather promoted reproduction of several species of coccinellid. Coccinellid adults were aphid density-dependent: an increase in aphid numbers by a factor of 23 produced a corresponding increase of 1.5 in adults. However, coccinellid larvae were aphid density-independent.

Coccinellid predators were influenced by local conditions, and their numbers varied greatly among different crops and within one crop. The distributions of adult coccinellids on corn were affected by availability of food, degree of insolation and elevation of host plant, and diversity of habitat boundaries. Adult longevity decreased and the amount of food eaten and the rate of food intake increased as temperature rose from about 17 to 35 C. Fecundity was reduced at low temperatures, whereas fertility was reduced at high temperatures. The rate of food intake, development, growth, and survival of larvae depended on the species of coccinellid, kind of food eaten, and temperature. Food efficiency for growth, food utilization, and the water content of adults were unaffected by temperature, and were similar in males and females.

INSECT IMPORTS AND EXPORTS

52

During 1967, 93,000 living insects were imported to the Institute from ten European, two Asian, and two North American countries; 54,000 living parasites and predators were sent to establishments in the 10 Canadian provinces for use against 8 insect pests and 4 noxious weeds; and 3,600 living insects of 16 species were shipped to 7 foreign countries for use against 10 pests.

Surveys and research abroad, undertaken by the Commonwealth Institute of Biological Control and sponsored by the Research Institute, Belleville, mainly concerned the insects *Adelges piceae, Pristiphora erichsonii, Coleophora laricella, Rhyacionia buoliana, Neodiprion sertifer, Argyrotaenia velutinana, Psylla pyricola, Rhagoletis pomonella, Tipula paludosa,* and *Thymelicus lineola;* and the plants *Rhamnus cathartica, Centaurea repens, Carduus nutans, Euphorbia esula,* and *E. cyparissias.*

SCIENTIFIC NAMES OF ANIMALS AND PLANTS

This list contains the scientific name of each species mentioned in the text and, where appropriate, the common name.

Acarus siro Linnaeus	grain mite
Acilius semisulcatus Aubé	water beetle
Acyrthosiphon pisum (Harris)	pea aphid
Adelges piceae (Ratzeburg)	balsam woolly aphid
Adelphocoris lineolatus (Goeze)	alfalfa plant bug
Aedes aegypti (Linnaeus)	yellow-fever mosquito
Aedes stimulans (Walker)	mosquito
Agabus erichsoni Gemminger & Harold	water beetle
Altica carduorum (Guérin-Méneville)	beetle
Ambrosia artemisiifolia Linnaeus	common ragweed
Anaitis plagiata (Linnaeus)	moth
Aphidius smithi Sharma & Subba Rao	parasitic wasp
Arctosa emertoni Gertsch	wolf spider
Argyrotaenia velutinana (Walker)	red-banded leaf roller
Blattisocius dentriticus (Berlese)	predatory mite
Calophasia lunula (Hufnagel)	moth
Carduus nutans Linnaeus	nodding thistle
Celerio euphorbiae (Linnaeus)	European spurge hawkmoth
Centaurea repens Linnaeus	Russian knapweed
Ceutorhynchus litura (Fabricius)	weevil

Cheyletus eruditus (Schrank)	predatory mite
Chrysolina hyperici (Forster)	beetle
Chrysolina quadrigemina (Suffrian)	beetle
Cirsium arvense (Linnaeus) Scopoli	Canada thistle
Clostridium brevifaciens Bucher	bacterium
Clostridium malacosomae Bucher	bacterium
Cnephia dacotensis (Dyar & Shannon)	black fly
Cnephia mutata (Malloch)	black fly
Coleophora laricella (Hübner)	larch casebearer
Colymbetes sculptilis Harris	water beetle
Culex restuans Theobald	mosquito
Culiseta inornata (Williston)	mosquito
Dytiscus fasciventris Say	water beetle
Euphorbia cyparissias Linnaeus	cypress spurge
Euphorbia esula Linnaeus	leafy spurge
Euxoa messoria (Harris)	dark-sided cutworm
Exeristes comstockii (Cresson)	parasitic wasp
Formica obscuripes Forel	western thatching ant
Gastromermis viridis Welch	nematode
Hydrochara obtusatus Say	water beetle
Hypericum perforatum Linnaeus	St. John's-wort
Hypocrita jacobaeae (Linnaeus)	European cinnabar moth
Itoplectis conquisitor (Say)	parasitic wasp
Leiophron pallipes Curtis	parasitic wasp
Lepidium sativum Linnaeus	garden cress
Leptinotarsa decemlineata (Say)	Colorado potato beetle
Linaria vulgaris Miller	yellow toadflax
Longitarsus melanurus Melsheimer	flea beetle
Malacosoma americanum (Fabricius)	eastern tent caterpillar
Muscidifurax raptor Girault & Sanders	parasitic wasp
Myrmica americana Weber	ant
Nasonia vitripennis (Walker)	parasitic wasp
Neodiprion lecontei (Fitch)	red-headed pine sawfly
Neodiprion sertifer (Geoffroy)	European pine sawfly
Orius tristicolor (White)	plant bug
Oryzaephilus surinamensis (Linnaeus)	saw-toothed grain beetle
Periplaneta americana (Linnaeus)	American cockroach
Pieris rapae (Linnaeus)	imported cabbageworm
Pikonema alaskensis (Rohwer)	yellow-headed spruce sawfly
Pristiphora erichsonii (Hartig)	larch sawfly
Pristiphora geniculata (Hartig)	mountain-ash sawfly
Prosimulium fuscum Syme & Davies	black fly
Pseudosarcophaga affinis auct. nec Fallén	parasitic fly
Psylla pyricola Foerster	pear psylla
Psylliodes punctulatus Melsheimer	hop flea beetle
Rhagoletis cerasi Linnaeus	European cherry fruit fly
Rhagoletis pomonella (Walsh)	apple maggot
Rhamnus cathartica Linnaeus	European buckthorn
Rhopalosiphum maidis (Fitch)	corn leaf aphid
Rhyacionia buoliana (Schiffermüller)	European pine shoot moth
Schizocosa avida (Walckenaer)	wolf spider
Senecio jacobaea Linnaeus	tansy ragwort
Simulium venustum Say	black fly
Spalangia cameroni Perkins	parasitic wasp
Tetranychus urticae (Koch)	two-spotted spider mite
Thymelicus lineola (Ochsenheimer)	European skipper butterfly
Tipula paludosa Meigen	European marsh crane fly
Tribolium confusum Jacquelin duVal	confused flour beetle
Typhlodromus fallacis (Garman)	predatory mite
Umbra limi (Kirtland)	mudminnow
Urophora cardui Linnaeus	fly
Xysticus gulosus Keyserling	crab spider

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Research Institute
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PROFESSIONAL STAFF

Administration

E. Y. Spencer, B.Sc., M.Sc., Ph.D., F.C.I.C.	Director
M. van Ysselstein, B.Sc.	Administrative Officer
M. L. Stone (Mrs.),[1] B.A., M.L.S.	Librarian

Bacteriology

C. L. Hannay, B.S.A., Ph.D.	Electron microscopy and cell cytology
E. B. Roslycky, B.Sc., M.Sc., Ph.D.	Microbiology and virology

Chemistry

D. M. Miller, B.Sc., M.Sc., Ph.D.	Biophysical chemistry
R. M. Krupka, B.A., M.A., Ph.D.	Enzyme kinetics
J. R. Robinson, B.S.A., M.S.A., Ph.D., F.C.I.C.	Radioactive tracers
A. N. Starratt, B.Sc., Ph.D.	Natural products
A. Stoessl, B.Sc., Ph.D., F.C.I.C.	Photochemistry and natural products
G. D. Thorn, B.Sc., M.A., Ph.D., F.C.I.C.	Organic chemistry and fungicides
A. Vardanis, B.Sc., M.Sc., Ph.D.	Comparative biochemistry and toxicology

Entomology

W. Chefurka,[2] B.Sc., M.Sc., Ph.D.	Comparative biochemistry and toxicology
B. E. Brown, B.Sc., M.Sc., Ph.D.	Biochemistry
D. G. R. McLeod, B.S.A., M.S., Ph.D.	Physiology and biochemistry
T. Nagai,[3] M.A., D.Sc.	Neurophysiology

[1] Appointed in 1967. Seconded from Departmental Library.
[2] Transfer of work to Gif-sur-Yvette, France, from August 1967 to August 1968.
[3] Appointed in 1967.

Fumigation

H. A. U. Monro, B.S.A., M.Sc., Ph.D.	Fumigation
E. J. Bond,[4] B.S.A., M.Sc., Ph.D.	Fumigation and toxicology
T. Dumas, D.C.E., M.Sc.	Analytical chemistry

Plant Pathology

E. W. B. Ward, B.Sc., M.Sc., Ph.D.	Histology and physiology
L. T. Richardson, B.A., M.A., Ph.D.	Fungicides
G. A. White, B.A., M.Sc., Ph.D.	Plant biochemistry and fungicides

Plant Physiology

W. H. Minshall, B.S.A., M.Sc., Ph.D.	Herbicides
M. A. Venis, B.Sc., Ph.D.	Plant biochemistry and growth regulators

Soil Pesticide Behavior

C. R. Harris, B.A., M.A., Ph.D.	Entomological toxicology
J. R. W. Miles, B.Sc.	Analytical chemistry
M. K. Mukerji,[5] B.Sc., M.Sc., Ph.D.	Ecology
C. M. Tu, B.Sc., M.Sc., Ph.D.	Microbiology

Departure

W. A. Andreae, B.Sc., M.Sc., Ph.D. Died October 14, 1967	Auxins

VISITING SCIENTISTS

L. C. Terriere, Ph.D., June–August 1967	Insect biochemistry

National Research Council postdoctorate fellows

K. Hellenbrand, D.Sc., 1967–68	Enzyme kinetics
I. Ishaaya, B.Sc., M.Sc., Ph.D., 1966–68	Insect biochemistry
E. Taniguchi, Ph.D., 1965–67	Plant biochemistry

Canada Council postdoctorate fellow

G. F. Collett, D.Sc., 1966–67	Plant physiology

Graduate students

R. Dejardin, B.Sc., 1966–68	Plant pathology
J. Wood, B.Sc., 1966–68	Plant pathology—fungicides
A. Morello, Pharm. Chem., 1964–68	Biochemistry—toxicology
E. D. Murray, B.Sc., M.Sc., 1966–68	Biochemistry—toxicology

[4] Transfer of work to Carshalton, England, from August 1967 to August 1968.
[5] Appointed in 1967.

INTRODUCTION

A section concerned with soil pesticide behavior was added to the Institute. Among the results to date was the isolation of some soil microorganisms that are able to degrade specific organochlorine insecticides to nontoxic residues. Research continues on the mode of action of toxicants (fungicides, herbicides, and insecticides) and certain biologically active naturally occurring material, and on the chemical characterization of these materials in collaboration with other research establishments.

The sudden passing of Dr. W. A. Andreae, one of the original staff members of the Institute, was a shock to us all.

E. Y. Spencer
Director

BACTERIOLOGY

Structure and Composition of the Insecticidal Parasporal Body of *Bacillus thuringiensis*

3

Problems arose in growing some of the strains of *Bacillus thuringiensis* for crystal production because they became so unstable that they no longer formed crystals. However, this was overcome when it was shown that the instability was aggravated by the medium and could be overcome by redesigning a semisynthetic one.

With the development of a simpler method of crystal purification, methods of dispersing them are now being investigated for ultimate fractionating and testing for homogeneity and toxicity.

Bacteriocin in the Rhizobia Bacteria

16

Several strains of rhizobia bacteria and some strains of the cowpea cross-inoculation group were shown to produce bacteriocin-like substances, although inconsistently. Many variables were examined, including a number of mutagenic agents, but none stabilized production. Inhibition zones of several showed no inhibition of soybean germination.

Influence of Bacteria on Indoleacetic Acid Metabolism

Two bacterial isolates from pea root tissue were found to reduce the rate of indoleacetic acid metabolism in the tissue. The chromogenic and nonchromogenic bacteria have been partly described culturally, morphologically, and physiologically.

BIOPHYSICS

The Physical–Chemical Nature and Functioning of the Cytoplasmic Membrane

By use of a simple system, namely the movement of monosaccharides in human erythrocytes, a set of kinetic data on a single transport system was produced. Being comprehensive and covering as many aspects as possible, the data now serve as one criterion against which to judge various transport mechanisms that are proposed from time to time.

ELECTRON MICROSCOPE MISCELLANEOUS STUDY

Surface Structure of Black Fly Wings

Examination of the wings of five black fly species supplied by the Entomology Research Institute has revealed a remarkably constant distance between the regularly raised, small buttons on the surface, and a slight difference between species. Examination of the structure showed that each raised button is connected by a wax pore canal to an epithelial cell below the cuticle.

FUMIGATION

Absorption and Metabolism of Fumigants by Insects

1

From a study of the absorption of fumigants by insects a direct relationship was found between fumigant uptake and toxicity. Oxygen content of the atmosphere affected the uptake. This was particularly significant with phosphine where even small amounts of oxygen greatly increased absorption.

Fumigant-resistant Insects

It has been conclusively established that resistance of granary weevil adults reaches a plateau of resistance to methyl bromide as a result of unrelaxed selection, the selected strain being eight times as resistant as the unselected strain. Preliminary results with the same insect, by use of phosphine, have indicated that a plateau is reached in a much shorter time.

Embryology of the European Pine Sawfly in Relation to Susceptibility to Fumigants

From an intensive study of the European pine sawfly it was found that during the first 4 days after being laid, the eggs were extremely susceptible to methyl bromide and were killed by less than half the dosage required to kill older ones. During this particularly susceptible 4-day period it was noted that the germ band was undergoing formation, rendering the eggs more vulnerable. Observations have also shown that embryos in eggs laid at different times during the season do not necessarily enter hibernation in the same stages of development.

INSECT PHYSIOLOGY AND TOXICOLOGY

Mechanism of Oxidative Phosphorylation

The boiled supernatant from thoracic mitochondria of flies, or liver or heart mitochondria of mice, was shown to contain a factor that stabilizes and prevents the rapid decline of oxidative phosphorylation normally associated with aging. It mimics the stabilization effect of bovine serum albumen, EDTA, and substrate. It is dialyzable and has no species specificity. This information has provided the basis for a study of the mechanism of action of a new class of insecticides.

Pharmacologically Active Substances in Insects

2

The study of different aspects of the new neuromuscular transmitter substance present in the gut-innervating nerves of the cockroach was continued. It included the morphology of the musculature and innervation of the roach hindgut, electron-microscopy of the neuromuscular junction, and isolation and characterization of a particulate fraction containing the transmitter substance. Following the demonstration in vivo of an enzyme inactivator of the substance, an in vitro system has now been perfected which will assist in elucidating the nature of the transmitter substance.

Collaboration with the Research Institute, Belleville, on an intracellular study of the electrical characteristics of the visceral muscle fibers of the cockroach has been completed. With the filling of the vacancy for a neurophysiologist a more intensive study is now in progress.

Glycogen Synthesis in Insects and Mammals

27, 28

The rapid changes in glycogen utilization and synthesis in certain insects prompted an initial study of the control mechanisms of biosynthesis, storage, and utilization. The investigation is now concerned with a comparison of the particulate glycogen – glycogen synthetase complex from mouse liver. Synthetase activity of particulate glycogen from livers of starved animals was more dependent on the addition of exogenous primer than that from fed animals.

Isolation and Identification of Insect-feeding Stimulants and Attractants

Feeding tests carried out at the Research Institute, Belleville, indicated a slight preference for the hydrocarbon fractions from *Euphorbia* spp. However, subsequently it was shown in the light of the distribution of hydrocarbons in plants that it was unlikely to be the only host recognition factor. Further work here on the constituents of *Euphorbia polygonifolia* led to the isolation of ceryl alcohol, two similar unidentified aliphatic alcohols, and a triterpene.

Biochemistry of Insecticide Resistance

26

To examine the development of resistance to insecticides by insects from the point of view of the mechanism of transcription and translation of the genetic code, a study of the isolation and properties of polyribosomes from susceptible flies was started. Their involvement in in vivo protein synthesis and sensitivity to puromycin was examined. A comparison with flies resistant to DDT is now in progress.

Mode of Action of Photoperiod in Determining Growth and Development in Insects

9

The European corn borer has a larval diapause in the fifth instar which is induced and terminated by the appropriate photoperiodic regime. The changes in five variables were studied: blood trehalose, blood protein, gut glycogen, gut paraldehyde fuchsin (PAF) granules, and lateral neurosecretory cells. A negative correlation between blood trehalose and gut PAF granules and a positive correlation between gut glycogen and blood trehalose was found. These relationships held for a 12:12 photoperiod but not for a 16:8 photoperiod.

Acetylcholinesterase

7, 8

As part of the study of the mechanism of action of the hydrolytic enzyme acetylcholinesterase the measurement of H_2S released from thiolacetic acid catalyzed by this enzyme was investigated. Because the catalytic efficiency was low, detailed studies were not practicable, and a new approach with C^{14}-labeled acetate is being developed. In the meantime, an analysis of the kinetic behavior of fly head cholinesterase is in progress for ultimate comparison with the analysis of results obtained from the study of mammalian cholinesterase.

Mode of Action of Organophosphorus Insecticides

11, 12, 13, 18

Following the finding that the *cis* isomer of mevinphos was 100 times better as an inhibitor of cholinesterase than the *trans* isomer, and that the two geometrical isomers of Bomyl[6] were equally good inhibitors, a possible explanation relating the spatial configuration of the isomers and the enzyme was postulated. Subsequent degradation studies showed that carboxyesterases had little effect, and no potentiation in toxicity was shown with triorthocresyl phosphate by contrast with that found with malaoxon. *Cis* mevinphos was degraded by mouse liver homogenates to desmethyl mevinphos and was glutathione-dependent, whereas *trans* mevinphos yielded dimethyl phosphate and was independent of glutathione. The isomers of Bomyl were also degraded to dimethyl phosphate by a system differing somewhat from that for *trans* mevinphos.

FUNGAL PHYSIOLOGY AND TOXICOLOGY

The Mode of Action of Dithiocarbamate Fungicides

15

In a study of the activity of dithiocarbamates a series of *N*-alkyldithiocarbamates were synthesized. The toxicity to the test organism *Pythium ultimum* Trow in the control of preemergence damping-off decreased progressively from the methyl homologue to the hexyl and did

[6] Allied Chemical Corp.

not exist from the octyl to the decyl. Phytotoxicity, indicated by failure of pea seedlings to emerge from the soil, decreased progressively with increasing alkyl group from the methyl to the amyl homologue, and then decreased to the decyl.

An Analytical Method for Captan

An analytical method for the fungicide captan is based on measuring the product resulting from heating with resorcinol monomethyl ether. A tentative structure for the main product, 3,6-dimethoxyxanthen-9-thione-*S*-oxide, is proposed.

Effects of Fungicides on Soil Microflora

14

An ecological study of the selectivity of certain organic mercurial fungicides toward soil fungi indicated that some fungi were resistant and that they included both saprophytes and potential pathogens. Three new systemic fungicides showed differing toxicities to the test organisms.

Mode of Action of the Toxin from *Bipolaris sorokiniana*

24

The sesquiterpinoid dialdehyde, helminthosporal, isolated from the root rot organism *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. appears to be essential to disease development on barley seedlings. It inhibits respiration of various plant tissues. At the mitochondrial level it has a dual effect on electron and energy transfer. It has been found to have gibberellin-like activity in the barley endosperm test, but is weaker than that of the aldehyde-alcohol derivative, helminthosporal. However, the air oxidation product (mono acid), helminthosporic acid, inhibits the gibberellic acid induced synthesis of amylase and may be more important in phytotoxicity than helminthosporal.

Zinniol, a Phytotoxin from *Alternaria zinniae*

19

After a phytotoxic component was found in the culture filtrate from the phytopathogenic fungus *Alternaria zinniae* Pape, the structure of the phytotoxin was shown to be 1,2-bis(hydroxymethyl)-5-(3,3 - dimethylallyloxy) - 3 - methoxy - 4 - methylbenzene. Mannitol was isolated from the mycelium of *A. zinniae*.

Metabolites of *Alternaria solani*

31

Two further pigments of the mold *Alternaria solani* (Ell. & Martin) Jones & Grout have been characterized. One is 7-monomethylether of 2-methylxanthopurpurin and the other, an unusual structure, 1,2,3,4-tetrahydro-2,3(or 4),5-trihydroxy-2-methylanthroquinone (altersolanol B). The latter and altersolanol A (the corresponding pentahydroxy derivative) may have significance in studies of aromatic metabolism in molds.

Physiology of Psychrophilic Fungi

31, 32

Following physiological studies of the highly psychrophilic *Sclerotinia borealis* Bubák & Vleugel, an investigation of morphological effects of supraoptimal temperatures showed that growth was arrested at 25 C. Hyphal tips appeared to be the site of greatest heat sensitivity, and at the optimum temperatures new growth arose at some distance behind these tips.

For the low-temperature basidiomycete W_1, the physiological requirements were not as clear as for *S. borealis*, possibly because of less extreme temperature requirements. However, it seems that with this fungus, as with *S. borealis*, growth becomes uncoupled from respiration above the maximum growth temperature.

Short-time experiments with labeled glycine showed that the W_2 isolate of the low-temperature basidiomycete formed HCN rapidly, but it was initially present in a combined form. A study of this form has been complicated by its instability.

Antifungal Agents in Barley

22, 34

Following the identification of some antifungal components, hordatines, from barley coleoptiles grown in the dark, a recent study showed a reduction of hordatines when coleoptiles were grown in day-

light. However, another compound of basic and aromatic character appeared. It is now under investigation.

Miscellaneous Items

20, 23

m-N-Ethylaminobenzoic acid was reported elsewhere to be identical with a substance isolated from an amended soil and toxic to lettuce and other commercially important plants. An authentic sample was synthesized here and shown to be different from that reported earlier.

Collaboration is under way with the Research Station at Winnipeg in concentrating and identifying technically one of the factors appearing as a metabolic product from a rust-resistant, inoculated wheat variety.

We collaborated with the Plant Research Institute to characterize the sterol and fatty acid components of the mycelium of *Fusarium oxysporium* Schlecht.

PLANT PHYSIOLOGY AND TOXICOLOGY

Interaction of Plant Growth Regulators in Protein and Nucleic Acid Metabolism

29, 30

The examination of the hypothesis that auxins may exert their action on protein biosynthesis through auxin–protein complexes was continued. Pea bud histones were separated into a lysine- and an arginine-rich fraction. The former had a low affinity for 2,4,5-T and 2-chlorophenoxyacetic acid, whereas the latter gave biphasic binding curves indicating a set of low- and high-affinity binding sites. We are now developing an improved technique that we hope will yield larger quantities of the more native form of salt-dissociated histone.

Although auxin induction of the benzoylaspartate conjugation system in pea segments was shown to be prevented by streptomycin and several compounds having structural affinities similar to streptomycin, such as the polyamines spermine and spermidine, magnesium ions have been shown to neutralize this inhibition. Since spermine can replace the indoleacetic acid requirement for continued growth of plant tissue, it may be of value in the study of the mode of action of plant growth substances.

Metabolism and Mode of Action of Indoleacetic Acid and Auxin Type of Herbicides

It was thought that phenolics, by stimulating the indoleactic acid oxidation, controlled the level in plant tissue and therefore growth activity. However, it has now been shown that the effects of phenolics on growth activity of applied indoleacetic acid are related to the changes of concentration in solution rather than the accumulation of auxin in the tissues.

Metabolic Root Pressure and Uptake of Triazine Herbicides

10

Although translocations across the roots of detopped tomato plants of triazine herbicides and other solutes were increased by the addition of fertilizer N, preliminary experiments showed that there was no increase in the amount in the shoots when whole plants were used.

SOIL PESTICIDE BEHAVIOR

Soil Insecticide Behavior

4, 5, 6, 17, 25, 33

The effect of factors such as moisture, temperature, and type of soil on the efficiency of some organochlorine and organophosphorus insecticides in the control of soil insects as well as in the persistence of the insecticides was studied. After laboratory studies, application of findings proved to be highly efficient in the con-

trol of the dark-sided cutworm in the field.

Studies on absorption and translocation of cyclodiene organochlorine insecticides indicated that the uptake was not sufficient to cause concern, except for root crops that were grown for animal feed. The persistence in soil has been shown to be influenced by moisture, temperature, soil type, crop, and microflora. It has also been found that there is a variation in activity within organophosphorus insecticides between soil types at different moisture levels. From nearly 100 pure cultures of soil microorganisms assayed for aldrin-degrading activity most showed some capacity for conversion to dieldrin: some showed immediate activity, others exhibited an initial lag period. Of greater potential value was the discovery of a number of fungi, actinomycetes, and bacteria that, following conversion of aldrin to dieldrin after a period of adaptation, degraded the dieldrin to products not detected by the current assay methods.

Population Dynamics of the Cabbage Maggot

With the object of developing ecological life tables for successive generations of the cabbage maggot and ultimately producing a mathematical model to gain an insight into population mechanisms and finally more efficient control, plots and sampling were designed. Suitable data were gathered for the first year.

PUBLICATIONS

Research

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3. Hannay, C. L. 1967. The dissociation of *B. thuringiensis*. Can. J. Microbiol. 13:1566–1568.
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Analytical Chemistry Research Service
Ottawa, Ontario

PROFESSIONAL STAFF

R. B. Carson, B.A., B.Sc., M.Sc., F.C.I.C.	Director
I. Hoffman, B.Sc., M.A., Ph.D., F.C.I.C.	Inorganic chemistry
D. A. Shearer, B.A., M.A., Ph.D., F.C.I.C.	Organic chemistry
D. S. Gamble, B.Sc., M.Sc., Ph.D.	Physical chemistry

Pesticide Residues

H. V. Morley, B.Sc., Ph.D.	Organochlorines
R. Purkayastha, B.Sc., M.Sc., Ph.D.	Herbicides

INTRODUCTION

This is a brief summary of the work of Analytical Chemistry Research Service for 1967. The previous report covering the period 1959–1966 outlined the functions of the Research Service and summarized the work done during those years.

Our purpose continues to be the development of expert knowledge in analytical chemistry for application to agricultural problems and the provision of cooperation in analytical chemistry to Branch establishments as required. In the latter connection the Research Station at Lacombe was supplied with analytical data on some 500 animals (2,000 samples) from a study of the genetic aspects of swine carcass evaluation.

The work on pesticide residues has been expanded by the provision of an organic chemist who will specialize in methods for measuring herbicide residues, their metabolites, and breakdown products.

R. B. Carson
Director

INORGANIC CHEMISTRY

Selenium in Biological Materials

A precise fluorometric method for the determination of selenium at the level of parts per billion has been developed and successfully tested by statistical methods to ensure a high degree of "ruggedness" and "reproducibility." The method will be tested further by collaborative studies under the sponsorship of the Association of Official Analytical Chemists.

To gain a deeper understanding of the role of selenium in animal nutrition and in certain selenium-deficiency diseases, it was desirable to develop analytical methods to differentiate among the three main forms of selenium present (Se^{IV} or selenite, Se^{VI} or selenate, and organically bound selenium). Initial results have been very encouraging.

Studies on different ways of preparing animal tissues for selenium analysis showed that small but definite losses of selenium occurred when samples were prepared by the freeze-drying technique.

A joint study with the Animal Research Institute on the distribution of selenium in the tissues of steers from the Kapuskasing herd has been completed. The animals received one or two injections of a selenium preparation to combat nutritional muscular dystrophy and were slaughtered at intervals over a 20-week period. Muscle, liver, kidney, heart, and lung tissues were analyzed for selenium. Kidney tissue was highest in selenium, followed by heart; liver and lung contained 1–2 ppm; and the other tissues contained less than 1 ppm, on a dry basis.

The distribution of selenium between the prenatal fetus and the mother ewe is under investigation.

Multielement Analyses by Atomic Absorption Spectroscopy

There has been a decided trend towards research involving multielement interactions in biological systems, and it is now practical to consider such projects on the basis of time, ease, and cost.

By use of atomic absorption spectroscopy with both acetylene–air and nitrous oxide – acetylene burners and hollow cathode lamps for Na, K, Ca, Cu, Fe, Mg, Mn, Zn, Mo, Al, Si, and Zr analyses, valid procedures for most of these elements have been developed and tested. In Ca analysis greatest sensitivity and accuracy were obtained in the presence of lanthanum salts using the high-temperature nitrous oxide – acetylene burner.

In cooperation with the Food Research Institute a multielement study was carried out to determine the distribution of mineral constituents in Netted Gem potato tubers grown in 12 locations across Canada. The purpose of the project was to determine if there was a relationship between texture of French fries (mealiness and firmness) and differences in mineral content. Some differences were found between eastern and western potatoes and the data are now being examined statistically.

ORGANIC CHEMISTRY

Pheromones of the Honey Bee

The production of 2-heptanone in the mandibular glands of worker bees starts only when the bees begin foraging. Therefore, although 2-heptanone can act as an alarm substance, other functions for the pheromone are being sought.

The sting pheromone of four species of *Apis* from North America, Europe, and the Far East was investigated by gas chromatography. Isopentyl acetate was found in all four, but the amount varied from species to species. 2-Heptanone, which provokes alarm throughout the genus, was found only in *A. mellifera.*

Microanalysis

The Coleman semimicro automated nitrogen analyzer (MK.II) was evaluated by tests on a variety of agricultural samples. By adding a suitable catalyst the method used with this instrument, although less precise than the macro Kjeldahl method, compares favorably with it.

Studies with the AMINCO carbon and hydrogen analyzer showed that it provided a rapid accurate technique for the determination of carbon in soil organic matter if vanadium pentoxide was used as a catalyst.

Analytical Method for Determining Amino Acids

Analysis of amino acids by the gas chromatography of their *N*-trifluoroacetyl methyl esters is being developed. Using a neopentyl glycol succinate polyester liquid phase and temperature-programming, 20 amino acids can be separated in a single

run. The method is being applied to samples of corn, barley, and other agricultural products.

Ascorbic Acid and Carotene Content of Plants Grown in the Eastern Arctic

Leaf and root vegetables grown at the Research Substation, Fort Chimo, Que., during the 1964 and 1965 crop seasons were assessed agronomically and analyzed for ascorbic acid and carotene. Analyses were also performed on leaves, stems, roots, and berries of a number of native plants grown in the Ungava Bay region. Methods of analysis valid for an isolated area were developed and tested earlier in our laboratories.

Although field conditions, soil, and climate were not ideal for vegetable production, satisfactory results were obtained in plastic-covered crop shelters or in the open field when plastic mulch was used. It was established that many varieties of vegetables containing adequate amounts of carotene and vitamin C can be successfully grown in this area. Some native plants were found to be remarkably rich in vitamins. They represent a potentially valuable natural resource, which could be utilized under survival conditions or as required to ensure proper nutrition in the far north.

The complete details of this study have been prepared as a departmental publication.

Methylmalonic Acid

Sometimes urinary methylmalonic acid (MMA) excretion is used as a criterion of vitamin B_{12} nutritional status. During an investigation of the incidence of vitamin B_{12} malabsorption in sows that had produced small, weak litters, urinary MMA concentrations were studied. A published procedure for use with human urine had to be extensively modified before it could be used for sows' urine.

PHYSICAL CHEMISTRY

Maleic Hydrazide Determination

The photometric analysis of trace amounts of hydrazine with *p*-dimethylaminobenzaldehyde is subject to a complex chemical equilibrium. A fairly complete, quantitative understanding of this system has been obtained by three types of experiment. These are photometric measurements of the colored product upon which the analytical method is based, solubility measurements of the *p*-dimethylamino-benzaldehyde in aqueous strong acids, and photometric measurements of this reagent in aqueous acid.

Using this information the existing method of analysis can be made more accurate and efficient. The adaptation of this method to lower hydrazine concentrations is being explored.

Moisture in Agricultural Products

A workable cold-trap system for our fluidized bed apparatus is now in use. The amounts of nonaqueous volatiles lost during drying have been measured at 25 C, 55–60 C, and 95–110 C. Experiments have been started to develop methods for measuring the amounts of water that can be removed from samples previously equilibrated with a known water activity. Plant material and model systems are both being used.

Although dextrose can take up and retain water, it does not by itself provide the key to moisture content problems.

Other appropriate experimental methods may include swelling volume measurements, calorimetry, and proton magnetic resonance measurements.

Complexing of Fe^{+++} by Soil Organic Matter

Photometric methods of analysis for total iron are many. The analytical chemical problem in these studies is that of distinguishing unbound iron from total iron in solutions containing Fe^{+++}, ligands, and complexes. The sodium ion form of zirconium molybdate cation exchanger has been used successfully for Fe^{III}–Na^{+} ion exchange equilibria. The nature of this ion exchange process and its usefulness for complexing studies are being investigated. Useful information about the chemistry of the iron solutions may also result.

PESTICIDE RESIDUES

Soils

The first phase of work aimed at investigating the variables likely to be encountered in the determination of organochlorine residues in various soil types in Canada has been completed. Factors investigated include solvent extraction systems; contact time between solvent and soil; blending, tumbling, and Soxhlet extractions, moisture content of soils; and the amount of coextractives. Fortification experiments using dieldrin-C^{14} showed that this commonly used technique for establishing extraction efficiencies is of questionable value. The knowledge gained from this work has been invaluable in setting up a check sample program for organochlorine residues in soils under the auspices of the National Committee on Pesticide Use in Agriculture.

Work is continuing on the breakdown and persistence of organochlorine residues in soils using C^{14}-labeled compounds.

Monuron residues were detected and estimated in soil treated in 1964. The determination was carried out by colorimetry and the presence of monuron was confirmed by paper chromatography.

Animal Products

Work has been started on the determination of BHC isomers and DDT derivatives and their breakdown products in beef fat. Evidence has been obtained that there is differential breakdown of BHC isomers in the animal.

Work is also in progress to develop a method for the estimation of nicotine residues in pigs. The need for this analysis arose from feeding trials in which nicotine was added to the diet.

HERBICIDES

Electrophoretic Behavior of some Herbicides

The following herbicides were studied by paper electrophoresis: dicamba, chloramben, 2,4-D; 4-(2,4-dichlorophenoxy) butyric acid; 2,4,5-T; 2-(2,4-dichlorophenoxy)propionic acid; MCPA; fenoprop, picloram; diuron and monuron. By selecting proper buffer systems, most of the herbicides mentioned were separated and identified on the basis of their characteristic mobilities.

The study will be continued with high voltage electrophoresis and thin-layer electrophoresis systems for better resolution and less separation time.

Effect of 2,4-D on Plant Proteins

The protein pattern of pea seedlings grown in a controlled environmental chamber is being examined by gel electrophoresis to study the possible formation and nature of complexes of auxin herbicides and proteins. This work is in an exploratory stage.

Oxathiin Derivatives

The sulfoxide derivative of 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin was synthesized. It had more biological activity than the sulfone analogue but less than the sulfide analogue.

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Engineering Research Service
Ottawa, Ontario

PROFESSIONAL STAFF

C. G. E. Downing,[1] B.E., M.Sc.	Director
K. Mitchell	Administration

Development and Advisory Section

J. E. Turnbull, B.S.A., M.S.A.	Head of Section Farm structures

Research Service Section

P. W. Voisey, A.M.I., Mech. E.	Head of Section Instrumentation
E. J. Brach, D.E.E., Dip. Mil. Electronics	Electronics
G. E. Timbers,[2] B.S.A., M.S.A.	Food process engineering

Technical and Scientific Information Section

D. J. Cooper, B.Sc. (Agr.)	Head of Section
G. F. Montgomery,[2] B.Sc. (Agr.)	

Departure

W. Kalbfleisch, B.E. Mech., B.E. Civil, B.E. Agr., M.Sc. Died June 18, 1967	Chief

INTRODUCTION

Developments in agricultural engineering in the Research Branch and the reorganization of the Engineering Research Service were implemented during the year. It is planned that the introduction of the changes will result in greater depth in engineering studies as well as greater breadth of the agricultural engineering program of the Branch.

The Engineering Research Service has been organized into functional sections of responsibility. The Research Service Section conducts experimental or developmental studies on new engineering concepts, systems, or equipment and collaborates with other scientists or engineers on research projects in which machines, equipment, and instruments are

[1] Appointed July 24, 1967.
[2] On educational leave, 1965 to 1967.
[3] Appointed May 23, 1967.

developmental in nature or are a significant aspect of the study.

The staff of the Development and Advisory Section is a group of specialists in the main areas of agricultural engineering, who are experienced and knowledgeable in the advancing frontiers of developmental and applied technology. The Development and Advisory Section is organized to carry out developmental engineering projects and to act as consultants or advisers to people in government, universities, and industry.

The staff of the Technical and Scientific Information Section reviews, abstracts, summarizes, and assimilates pertinent published reports and technical scientific articles to aid advisory engineers, provincial extension engineers, Research Branch officers, and in answering general requests.

Although our work in 1967 was limited to a portion of the engineering areas, as outlined in the balance of this report, other areas will be developed as qualified staff becomes available. A number of well-equipped laboratories and a general machine shop have been developed to support the research and development projects.

Mr. W. Kalbfleisch, who died in June, made special contributions to the program of research through the development of equipment, instruments, and machines for a wide variety of projects. He was particularly recognized throughout the world for his contributions in illumination and growth chamber developments.

C. G. E. Downing
Director

DEVELOPMENT AND ADVISORY

This new section has been established to promote the development of agricultural engineering in Canada. It will comprise a team of experts in the various specialized areas of agricultural engineering, to advise, consult, and cooperate with federal and provincial government departments, universities, and the agricultural industry. Field investigations and applied research projects are being established to develop and evaluate engineering materials, principles, and systems important to the agricultural industry.

A main project has involved interdepartmental consultation in the design of service buildings and research animal housing for the Research Branch. In 1965, this advisory project began with a literature study, field investigations, and consultation with universities, industry, and utilities in Canada, USA, and Europe. This initial phase was to evaluate up-to-date building designs and materials-handling systems for the Animal Research Institute in the "Greenbelt" of Ottawa. Proposals for mechanical systems, floor plans, and structures to meet the requirements of the Animal Research Institute scientists have been made and preliminary drawings prepared to clarify and supplement the written briefs to the Department of Public Works.

Concurrent with the detailed preparation of contract documents by private consulting engineers and architects, cooperation with the Animal Research Institute has been given in the preparation of additional information, including detailed designs for special facilities such as pens, stalls, cages, ventilation, feed systems, and waste removal. This also involves construction of pilot-model pens and stalls, and performance-testing of new building materials.

The new research buildings for animals incorporate many new principles and features, which are not yet accepted generally in the Canadian livestock industry. For example, the buildings are windowless and light-controlled; fans and inlets are designed to move ventilating air without admitting uncontrolled natural light. Feed components are weighed, loaded, mixed, delivered, and spread mechanically wherever individual animal feed intake is not recorded. Cattle pens and passages have slotted floors to help keep the animals clean with a minimum of labor. Manure can be stored up to 6 months to eliminate the need for winter

operations, and in liquid form is removed by pumps.

Other important activities included a building code workshop in cooperation with the National Research Council for the Ontario extension engineers. Advisory activities included design assistance to the Department of Public Works for a ventilation and a waste-disposal system in a beef unit at the Research Station, Fredericton, N.B., and cooperative planning of a beef housing research project at Lethbridge, Alta.

RESEARCH SERVICE

Plot Mechanization

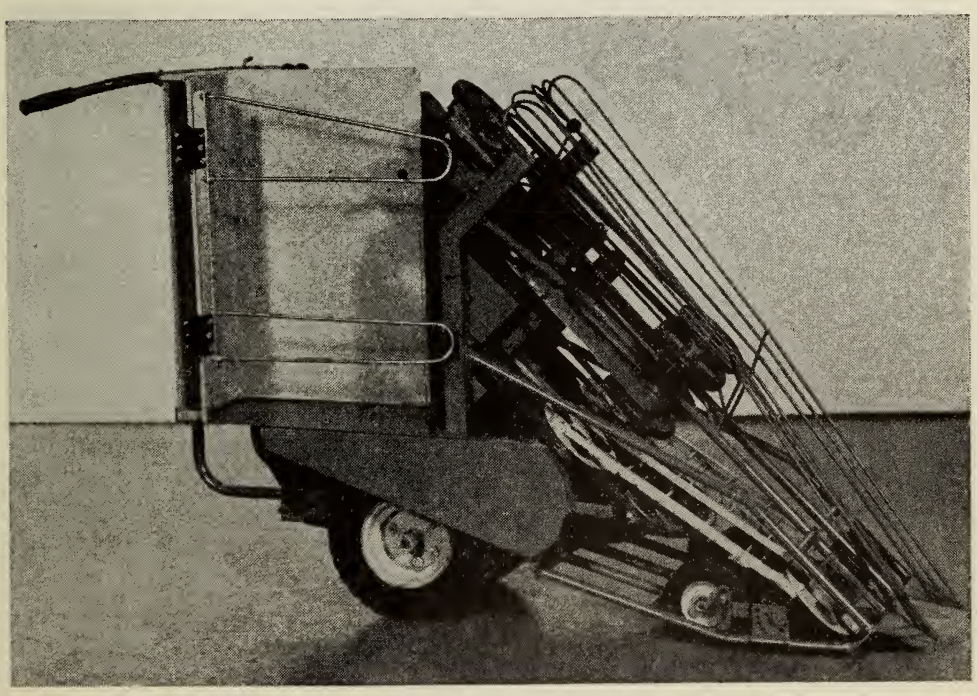
Machines have been completed for mechanizing the seeding, harvesting, and processing of experimental crops to reduce labor. Each machine was developed after surveys determined the overall requirements of the Branch.

A four-row spaced-plant seeder for corn and soybeans was completed and the development of a similar machine for cereals was started. A self-propelled four-row seeder for horticultural crops was constructed. This machine also applies controlled amounts of fertilizer and herbicides during the seeding operation.

An ultralow volume sprayer for insecticides was developed for treating potato plots used in entomological experiments. A portable winch-powered sledge carrying a spray boom was constructed for the Production and Marketing Branch. It applies a formaldehyde drench on garden plots to eliminate a fungus that causes wart disease and the potato cyst nematode found in Newfoundland.

Three seed-cleaning and grading machines based on the aspirated column principle were developed for experimental seed lots ranging from 20 to 200 g. A fumigant injector was also completed to treat small batches of seed.

The Ottawa single-row cereal harvester was completed and demonstrated at several stations. The machine was used



The Ottawa single-row cereal harvester for standing or lodged experimental plots.

successfully to harvest cereal and rape plots in both the standing and lodged conditions. It was found that two men could harvest two-row plots at the rate of one per minute without fatigue. Arrangements are under way to build the harvester commercially.

A study was begun to determine if the high cost of developing special plot machinery could be reduced by adapting commercially available machines produced in countries where small-scale farming is highly mechanized. Seven machines were purchased including harvesters, threshers, and binders. Early results show that some plot harvesting problems can be solved with this equipment. The modified machines will be used for demonstrations and evaluation by agronomists. A binder, manufactured in Italy, was modified so that its cutting height could be adjusted. It is satisfactory for harvesting cereal increase plots.

Assistance has been provided to solve other plot mechanization problems by modifying or adapting existing equipment to suit particular applications such as harvesting chufa.

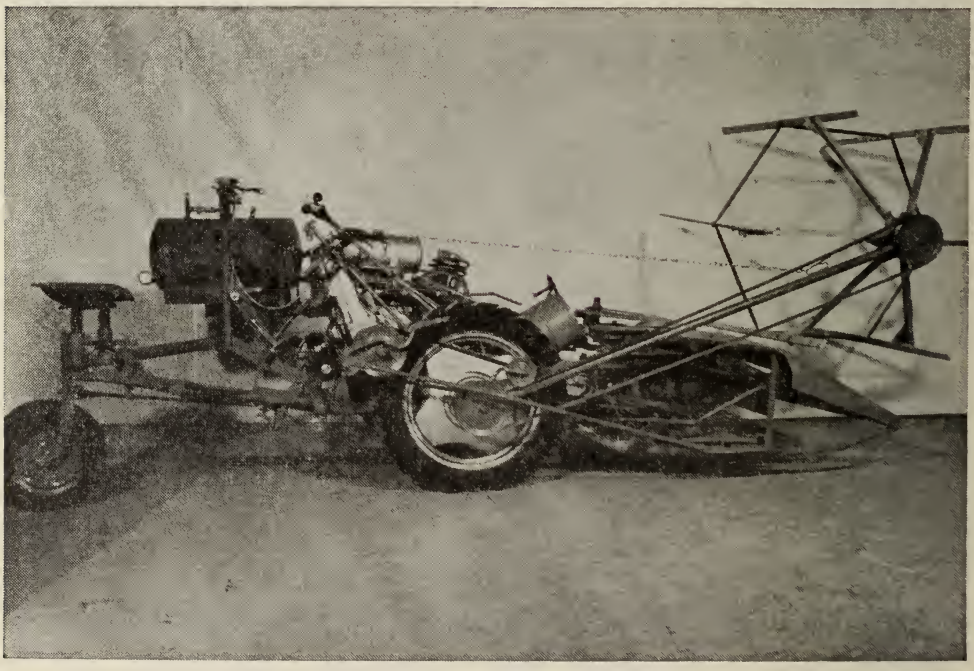
Environmental Equipment

Two environmental chambers for low-temperature animal physiology experiments were constructed. A controlled environment of —30 to +70 F ±1 F at wind velocities up to 10 mph and variable relative humidity was achieved. However, the problem of high noise levels inside the chambers was apparent and the unknown effect of this stress factor on animals must be taken into account in future designs.

Food Process Engineering

The performance of a fluidized-bed freezer drier for food products was improved by doubling the rate at which the air temperature was reduced. This made possible pilot-plant studies on dehydro freezing of fruits and vegetables.

A microwave oven was converted to cook food on a continuous basis. A conveyor belt that passes through the microwave cavity was installed. A water circulation system was also added to absorb the microwave energy and to prevent overheating when there is no product



A commercial binder modified for plot work.

passing through the oven. This water circulation system was also used to monitor temperatures inside the oven.

Instrumentation

A circular calculator was developed for converting calendar dates to number of days and vice versa so that animal gestation periods or other critical dates in agricultural production can be rapidly calculated. Arrangements have been made for the calculator to be produced commercially.

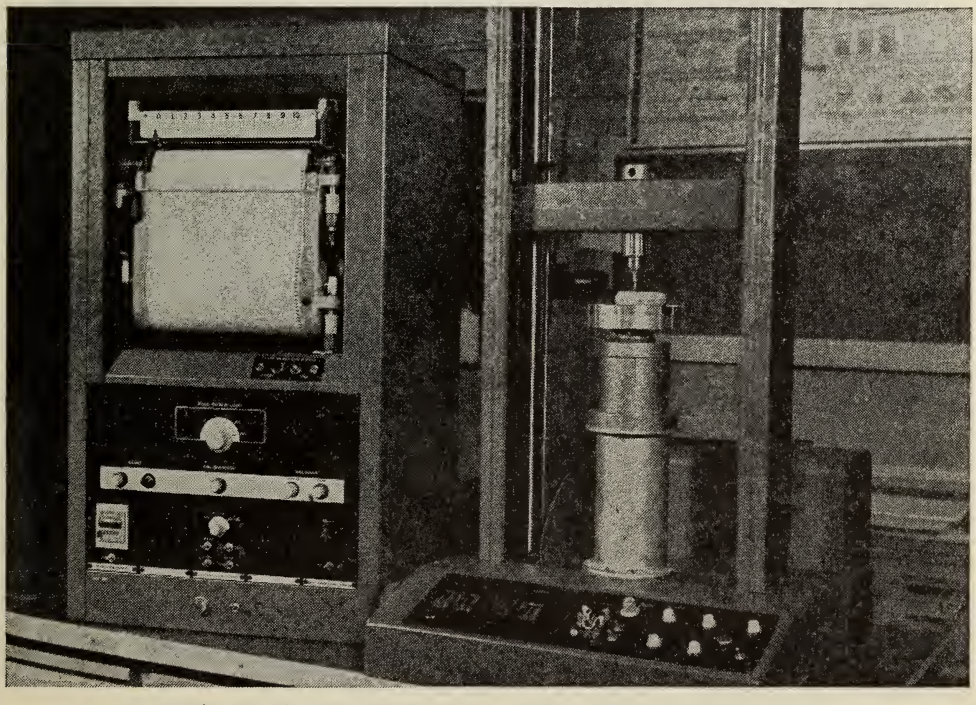
Simple measuring devices were constructed for the Production and Marketing Branch to assist in grading hog carcasses for size, shape, and backfat thickness. Photographic techniques were used to reproduce the linear scales required to minimize the cost of reproduction.

A special cylinder was constructed for storing vials of chicken semen in an atmosphere of oxygen at pressures up to 2,000 psi. Manual controls were arranged so that the rate of pressure rise or fall could be selected. The apparatus will be used to study methods of increasing the storage life of chicken semen.

A special cryogenic moisture trap was developed to produce dry gas to be used in chemical analysis. High efficiency was achieved by passing the gas through sixty 90° bends, which gave maximum heat transfer rates and maximum mixing of the gas. The traps were lightweight (14 g), compact, and easily mass-produced.

Several devices for measuring the texture of foods were completed including a variable-speed puncture tester, a meat-shearing device, and several accessories for a universal test machine to conduct preliminary studies on texture-measuring methods. An amylograph used for viscosity measurements was converted to record mixing torque electronically. The increased sensitivity made possible the study of gelling in 1% starch solutions.

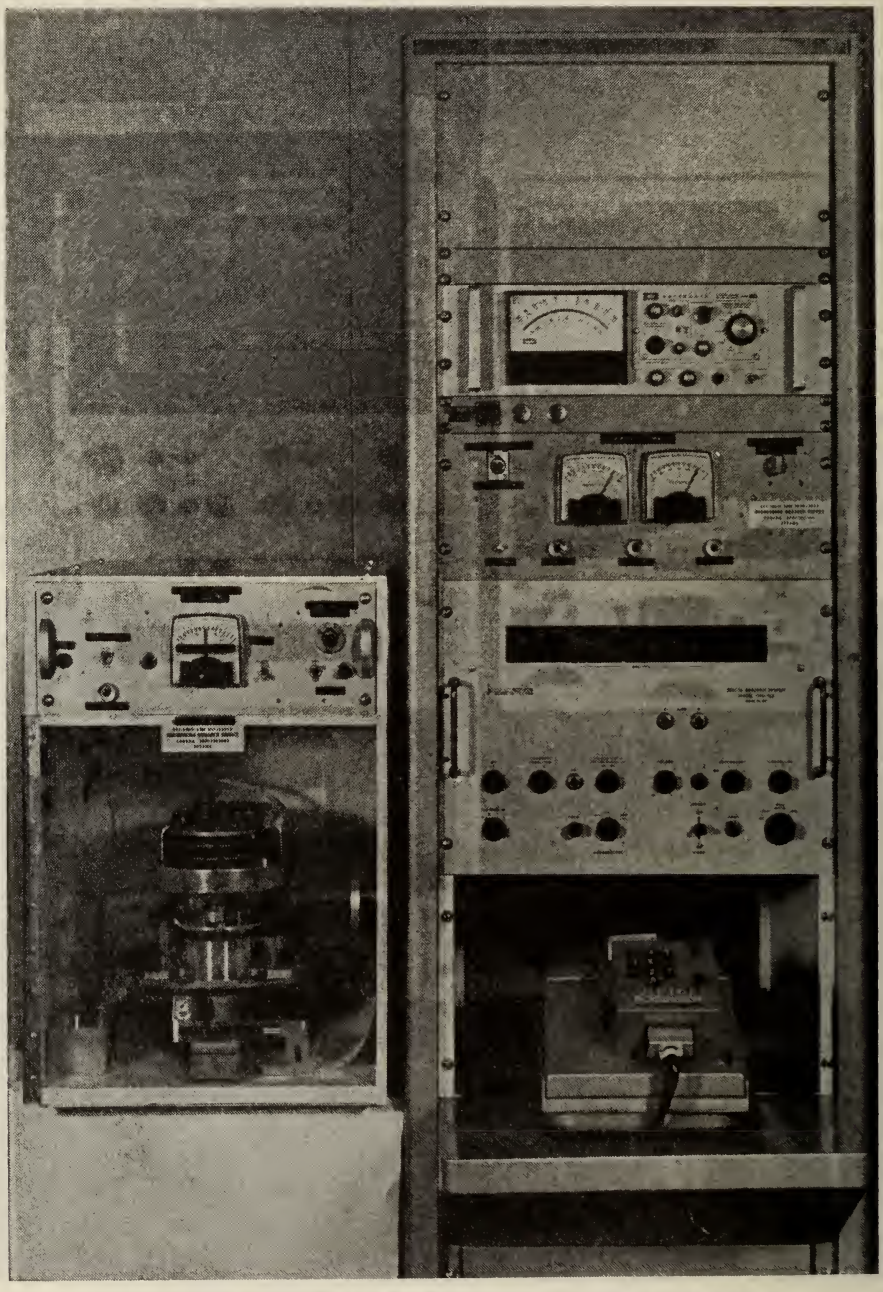
A study of the elastic properties of the potato tuber was undertaken to determine the relationship to French fry quality and



Measuring the behavior of the potato tuber under quasi-static forces.

the effect of storage time. It was found that the properties varied significantly within the tuber and among tubers but not among tubers of the same variety grown at different locations. The properties did not change significantly with storage times up to 6 months.

Development of the Ottawa electronic recording mixer for flour quality measurements continued. A new mixer was constructed, which can directly record energy absorbed by dough during mixing using 2-g flour samples. The design included features to control the bowl temperature



A system for recording energy absorption of foods during mixing.

before and during mixing and the mixing speed.

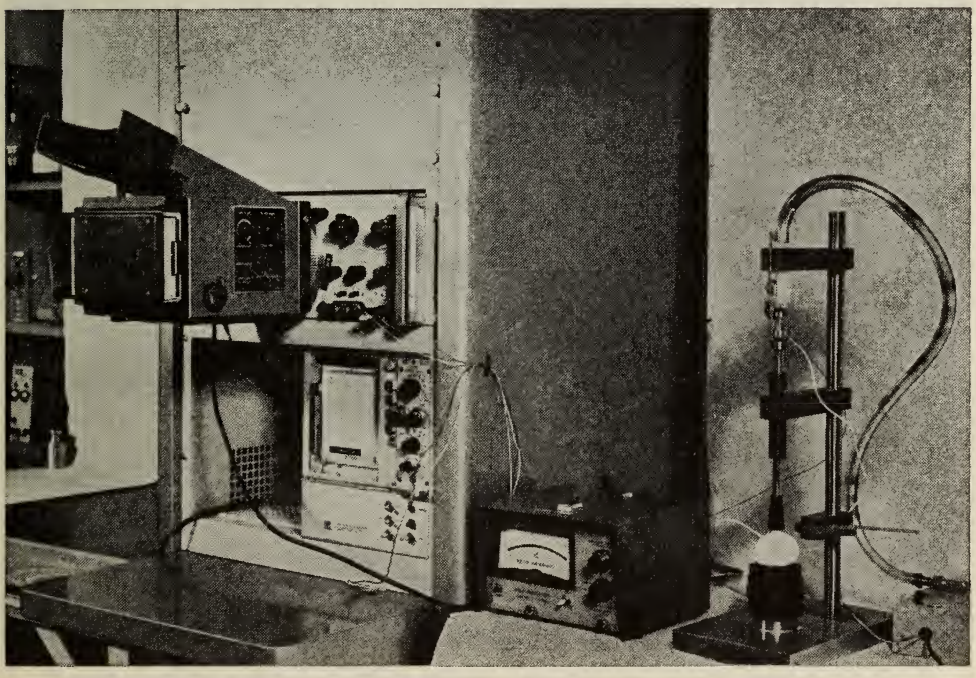
The search for a precise method of measuring eggshell strength was concentrated on impact measurements. A technique for monitoring the force imposed on the shell during an impact from a falling rod was devised. The output of an accelerometer on the rod was recorded by an oscilloscope. The results showed that the initial fracture at the inner surface of the shell, at the point of impact where the maximum stresses were located, occurred at low force levels. The shell fractured under impact forces of 20% of the force required under quasi-static conditions.

Electronics

A new seed counter was developed, which is capable of more precise counts than previous models. The possibility of two seeds close together counting as one seed was reduced by the rapid response of the photoelectric detector and the 600 count/sec rate of the counter. The new seed counter showed possibilities of becoming a universal instrument if the problem of feeding all types of seeds past the detector can be solved. A vacuum-operated dispenser was developed to solve this problem for very small seeds such as tobacco.

An instrument for recording radiant energy detected by an Epply pyrheliometer was developed for plant growth studies. An operational amplifier was used to drive a low-inertia integrating motor and the instrument was arranged to give instantaneous and integrated values of the radiant energy and to provide an output for continuous recording.

A unique electronic integration circuit based on pulsed techniques was developed to record the output of a differential thermopile. This detector, when placed in the ground, detects heat transmission through the soil. Since water moving in the soil carries heat, the instrument can be used to estimate the availability of water for plant growth.



Apparatus for recording the resistance of eggshells to impact.

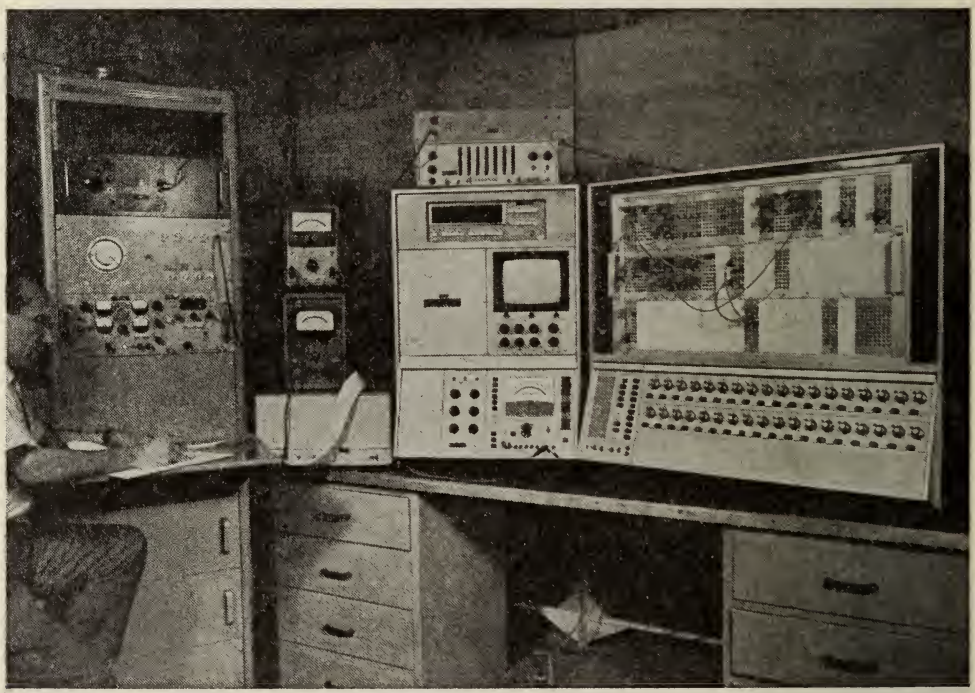
The absorption of ultrasonic energy by agricultural commodities was studied to determine if techniques can be devised to measure their moisture content rapidly and precisely. Preliminary investigations show that these techniques are a powerful tool for this purpose. The measurement of the moisture content of soil, butter, and dehydrated vegetables was accomplished successfully by use of complex laboratory equipment. Work is now in progress to devise a simple, inexpensive apparatus for field use.

A radio telemetry system for acquisition of physiological data was developed. A commercial receiver was used and special transmitters constructed. The work was restricted to winterhardiness measurements in fruit trees. However, once developed, the equipment and techniques will be universally applicable in plant and animal research by constructing a sensor for each new application. A big advantage of the telemetry equipment is that continuous monitoring of large numbers of physiological measurements can be accomplished with a minimum of labor. For example, the winterhardiness of 120 trees, the ambient temperature, and accuracy of the system were monitored automatically and the data were stored on punched tape for computor analysis. Special multiplexers were developed to do this with integrated circuit components. The low-cost units select each plant to be measured in turn so that the data can be broadcast by one transmitter.

Drafting and Shops

Production drawings of several units were completed so that the apparatus could be manufactured commercially.

Assistance was provided to numerous researchers by constructing special apparatus in the workshops. Some were minor items and others served as preliminary apparatus to provide information for further developments.



A radio telemetry system and analogue computer for the acquisition of physiological data from plants.

TECHNICAL AND SCIENTIFIC INFORMATION

The Technical and Scientific Information Section was established to communicate engineering information related to agriculture. It is coordinated with the Scientific Information Section, Research Branch, and collaborates with the Technical Information Services, National Research Council. Scientific reports, research articles, and technical and commercial literature is collected from all agencies and is used as source information for engineers and scientists in the Research Branch, for universities, for provincial departments of agriculture, and for organizations in the agricultural industry.

As a means of disseminating this information, a periodic newsletter is being planned that will report noteworthy research developments and items of general interest. Considerable planning has been done on the format of this publication.

In 1967, assistance was provided in the preparation of a brief for the Royal Commission on Farm Machinery, by compiling graphs and tables for illustrated talks, and by the collection and analysis of data in recently constructed animal research structures. Enquiries have been answered in the general field of agricultural engineering. The unit has been a source of agricultural engineering information to other information sections of federal departments. Assistance was supplied to the Museum of Science and Technology in the selection of farm equipment as museum pieces and for information on the history of agricultural equipment and practices.

LIST OF APPARATUS AND EQUIPMENT DEVELOPMENTS

	Establishment requesting work
Evaluation of light-fixture lifting mechanisms	Architectural and Engineering Section
A study of climate-controlled beef housing	E.R.S.
Garden plot sprayer	Production and Marketing Branch
Special gauges for grading hog carcasses	Production and Marketing Branch
An electronic recording amylograph	F.R.I.
Cyrogenic moisture traps	Anal. Chem. Res. Service
Automatic controls for selective animal feeding trials	Lethbridge
Survey and development of spaced-plant seeders	O.R.S.
Evaluation of commercial equipment for harvesting experimental plots	E.R.S.
Evaluation of commercial equipment for threshing experimental plots	E.R.S.
Rape seed crushing rolls	F.R.I.
Date calculator	A.R.I.
Temperature programming for cheese vats	F.R.I.
Harvesting of chufa	E.R.S.
Survey of equipment for mechanization of experimental plot work	E.R.S.
Moisture meter for X-ray diffraction system	S.R.I.
Study of environmental control in a poultry brooder house	A.R.I.
Investigation of the efficiency of light-trapped air inlets for poultry buildings	E.R.S.

Key
A.R.I.—Animal Research Institute
E.R.S.—Engineering Research Service
F.R.I.—Food Research Institute
O.R.S.—Ottawa Research Station
S.R.I.—Soil Research Institute

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Statistical Research Service
Ottawa, Ontario

PROFESSIONAL STAFF

P. Robinson,[1] B.A., Dip. Math. Stat., Ph.D.	Director
P. M. Morse (Mrs.),[2] M.A.	Head of Biometrics Section Bioassay, design of experiments
G. M. Weiss, B.S.A., M.S.	Head of Genetics and Computer Science Section Quantitative genetics
A. Bickle, Bau. Ing.	Systems and programming
M. R. Binns,[3] M.A., Dip. Stat.	Design of experiments, sampling
D. Clark, B.S.A.	Systems and programming
J. E. Krotki (Mrs.),[4] B.A.	Analysis coordinator
L. P. Lefkovitch,[5] B.Sc.	Quantitative ecology, numerical taxonomy
C. S. Lin,[6] B.S., M.S., Ph.D.	Quantitative genetics
A. Petrasovits, B.Sc., M.A.	Bioassay, organoleptic tests
E. C. Pielou (Mrs.), B.Sc., Ph.D.	Quantitative ecology
J. L. Prior, B.Sc.	Systems and programming
E. H. Reimer (Mrs.)	Systems and programming
G. J. Rowlands, M.A., Dip. Stat.	Design of experiments
C. S. Shih, B.Sc., M.Sc., Ph.D.	Design of experiments
B. K. Thompson,[7] B.Sc.	Genetics, systems, and programming
M. A. Wightman, B.Sc., B.Ed.	Systems and programming

Departure

J. R. Proctor, B.Sc., Dip. R.S.S. Resigned May 1967	Numerical taxonomy, ecology

[1] Seconded to Financial and Administrative Branch, October 1967 to April 1968.
[2] Acting Director from October 1967 to April 1968.
[3] Appointed September 1967.
[4] Appointed July 1967.
[5] Appointed April 1967.
[6] Appointed December 1967.
[7] On educational leave October 1967 to March 1968 at University of Waterloo, Ontario.

INTRODUCTION

The professional staff of the Statistical Research Service was increased by four members during the year, thus helping to meet long-felt needs in population dynamics, plant genetics, sampling, and multivariate analysis, as well as general design and analysis of experiments. A valuable contribution was also made by the six particularly good summer students, all from the University of Waterloo.

A summary of our 1967 research shows the impact of the computer in all phases of the work. This impact is all the more dramatic in that we have only lately become deeply involved in this field. Applied problems have expanded in number, subject matter, and complexity. The computer is being used by the statistical staff as a research tool in solving mathematical problems, in simulation studies, and in developing new statistical methods. Our rapidly growing library of statistical programs has evoked interest in several countries, and within the Department the increasing use of the computer for data analysis has led to a growing demand for advice on experimental planning and statistical methodology.

To help bridge the gap between the biologist and the computer, a series of introductory programming courses have been given across the country. The subject matter and method of presentation were specially tailored to the interests of the biologist. The courses ranged from 2 days to 2 weeks, and a special 3-day course for Research Managers included a discussion on management problems. The results have been highly successful, and the program will be continued for some time. So far, 126 scientists have attended these courses. This whole operation has indirectly affected project planning, not only in terms of methods and objectives, but also in terms of liaison with statisticians and computer scientists.

P. M. Morse
Acting Director

BIOMETRICS AND COMPUTER SCIENCE

Although advice and assistance on the planning, design, analysis, and interpretation of experiments and sampling studies constitute a large part of the biometrical work, there has perhaps been a shift in emphasis to multivariate problems and to mathematical aspects. Some of the highlights of the year's work follow.

Most of the computer work during the year has been done on the IBM SYSTEM/360 machines at the Central Data Processing Bureau. Various university installations have also been used. Existing programs for the Department's IBM 1620 machine have been converted to Fortran IV, ready for the change from the 1620 in 1968.

Mathematical ecology—A new method is being devised for classifying communities when, for each sampling unit, there is only a list of the species it contains. Intended as an improvement on Williams and Lambert's "Association-Analysis," the purpose of the method is to recognize recurrent groups of species. Another aspect being studied is the comparison between the number of such sampling units that are distinguishably different and the number expected on the null hypothesis that species are randomly and independently assigned to units. The deviation should provide a measure of the extent to which the assemblage of species fails to occupy all the available units.

Vector models of population growth have been formulated and their properties are being studied theoretically and by application to entomological data.

Applied population dynamics—Advice and assistance have been given on many problems in this field, mainly entomological. Among them were a continuing study of the oriental fruit moth, the sampling of ticks, various studies of mite populations in orchards, and the relation of mosquito counts to meteorological data.

Food research—Work has continued on the objective and subjective evaluation of foodstuffs. A specially designed experiment gave results that supported a model relating machine and panel assessments. The use of this relationship would make taste panels unnecessary in some situations.

Bradley's model for paired comparisons in a 2×2 factorial experiment has been extended to the 2×3 case for an experiment on meat tenderness. Methods for obtaining maximum likelihood estimates of the parameters under 11 different hypotheses were worked out, and a computer program was written for these procedures. Another extension of the model, which allows for tied ratings, is being applied to experimental assessments of cake-mix constituents; a general computer program is in the planning stage. These methods will be applicable also in other fields: for example, they have influenced the design of entomological experiments for studying apparent dietary preferences.

Bioassay—The computer programs for probit planes and higher-order surfaces have been used to study rates of effective degradation and the action of insecticides in different solvents. A model to investigate the incidence of resistance has been set up, although some problems in the estimation of the parameters have yet to be resolved. A computer program has been written to assist in the design of parallel-line quantal assays. Various time-mortality models have been evaluated for their suitability for a virus assay.

Quality control and inspection sampling procedures—A two-stage sampling procedure for the quality control of apples was drawn up for the Food and Vegetable Division of the Production and Marketing Branch. Practical comparisons are to be made between this procedure and the method used previously. The mathematical development of the sampling scheme suggested a simplification that would hold under certain hypotheses.

Growth curves—A logistic model was successfully used to characterize water absorption of click beetle eggs at various temperatures. Other applications of asymptotic regression equations included a complex study of plant growth, comparing parameters for different crops, varieties, and planting dates.

Lattice designs—A computer program was developed for the analysis and summarization of the Cooperative Grain Trials, and was used for the 1967 Wheat and Durum Wheat Trials. The program allows for analysis as randomized blocks, if appropriate, and will probably require little modification to handle the 1968 Cooperative Potato Trial results. A general program to analyze any type of square or rectangular lattice design was also developed.

Quantitative genetics—The diallel cross and discriminant function programs have been used extensively in the strawberry-breeding projects of the Ottawa Research Station. The complete diallel and certain partial diallel designs are being compared as screening techniques for breeding programs. The discriminant function has been used as a basis for selection rather than for evaluating results after selection has been practiced.

After research into some of the statistical procedures involved, a series of programs was prepared to analyze the extensive data that arise in complex animal-breeding studies. These programs estimate components of variance for a mixed model (random and fixed effects, crossed and nested classifications) with unequal subclass numbers. Estimates of a number of genetic parameters, including heritability and genetic correlation, are obtained.

A survey to evaluate the present swine carcass grading system and to study its possible improvement was initiated by various commercial, academic, and governmental bodies. Statistical analyses and summarization by computer were undertaken. The project required six man-months of systems, programming, and clerical time to meet the agreed deadline.

Several special programs were written to deal with selection studies on pigs and beef cattle, and also with studies of beef and swine carcass quality.

Mathematical methodology — Several statistical procedures require the maximization of a function of several variables, and various methods have been investigated and applied during the year. They include a Fibonacci search technique,

steepest-ascent procedures based on Davidon's method, and a simplex method proposed by Mead and Nelder. Several programs for matrix calculations have been prepared or adapted, and work continues on various aspects, including matrix functions, generalized inverses, and properties of eigenvalues.

General statistical programs—With the emphasis on building up a good library of general programs, and with participation by all the staff of the Service, much has been achieved. There are now 19 general programs fully documented, 8 others in use but not fully documented, as compared with 3 and 7 at the start of the year. Several other programs are being prepared. A complete list is circulated twice a year. Of particular interest are a very flexible general regression program, and a program (ALLREG) that gives output easily permitting calculation of regressions on any combinations of the independent variables. The nested analysis of covariance program handles many problems. The GENTAB program for calculating multiway tables and performing operations on them is already in consistent use calculating means and variances for a wide range of experiments and ecological studies. Other programs for multivariate analyses have been written or are under way, including programs for canonical correlation, principal component analyses, factor analysis, and time series analysis.

Software development and systems programming—Generalized input-output routines have been developed for use with the general programs on the SYSTEM/360 computers. Machine language subroutines were written for double precision integer arithmetic and for various binary operations that recur in scientific programming. A system for disc storage of our general library was developed to reduce input-output times and card-handling errors.

Data analysis—During the year the following job requests were handled using our general statistical computer programs on a production-run basis: 341 agronomic experiments, with an average of 4.5 variables per experiment; 122 sets of bioassay analyses; 384 regression and correlation studies; and 213 problems in numerical taxonomy, quantitative genetics, and other areas.

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Research Station
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PROFESSIONAL STAFF

W. N. MacNaughton, B.Sc., M.Sc., Ph.D.	Director
L. D. Bailey, B.S.A., M.Sc.	Soil fertility
R. L. Cliplef,[1] B.Sc., M.Sc.	Meats physiology
R. D. Dryden, B.S.A., M.Sc.	Agronomy and weeds
G. W. Dyck, B.S.A., M.Sc., Ph.D.	Animal physiology
B. J. Gorby, B.S.A.	Agronomy
A. T. H. Gross, B.S.A., M.Sc.	Forage crops
W. H. Johnston, B.A., B.Sc., M.Sc.	Cereal breeding
A. J. Klassen, B.S.A., M.Sc.	Barley breeding
G. W. Rahnefeld, B.Sc., M.Sc., Ph.D.	Animal genetics
J. H. Strain, B.S.A., M.Sc., Ph.D.	Poultry genetics
E. E. Swierstra, B.S.A., M.S.A., Ph.D.	Animal physiology

Departure

J. H. Thomas, B.Sc., M.Sc., Ph.D. Resigned February 1967	Forage physiology

INTRODUCTION

In this report no attempt has been made to describe our research in detail except in new work, or progress in long-term projects. Generally, only results are reported. Details may be found in research papers and reports listed in the publications section. Reprints may be obtained by contacting the authors.

Research is conducted to provide information on, and solutions to, problems associated with agricultural production, but no attempt is made to work in all fields or disciplines. The program is designed to supplement and complement the research conducted by other research stations and by the faculties of agriculture at univer-

[1] Appointed October 9, 1967.

sities. Emphasis is on genetics, breeding, and physiology in Animal Science; on breeding, physiology, and management in Plant Science; and on soil–plant relationships, nutrient uptake, soil fertility, cultural practices, crop rotations, and weed control in Soils and Agronomy.

The most significant staff change was the appointment of a scientist to start research on the physiology of meats.

W. N. MacNaughton
Director

ANIMAL SCIENCE

Beef Cattle

Selection for yearling weight—Selection based on yearling weight has been practiced in a closed herd of Shorthorns for 7 years. Estimated genetic changes were 4 lb for birth weight, 9 lb for weaning weight, and 52 lb for yearling weight. Selection for yearling weight has resulted in an increase of 7.4 lb/year and this represents a realized heritability of 36%.

Crossbreeding for beef production—Compared with calves from selected lines of purebred Shorthorns, crossbred bull calves (Brown Swiss × Shorthorn) were 10, 95, and 169 lb heavier at birth, weaning, and 11 months of age. On slaughter the crossbreds produced 4% more trimmed boneless retail cuts and returned $4.14 more per 100 lb of cold carcass weight than purebreds. Crossbred heifer calves were 8, 88, and 127 lb heavier than purebred calves at birth, weaning, and 1 year of age.

Crossbreeding and calving—When Shorthorn cows were bred to Brown Swiss bulls, 62% of them calved normally (without assistance), 19% required some assistance, and 19% calved with difficulty. Corresponding percentages for cows producing Shorthorn calves were 76, 18, and 9. The average weight of crossbred calves was 90.3 lb compared with 73.5 lb for purebred calves.

Controlled environment vs. open sheds for feeder steers—Hereford steer calves housed in a slotted-floor controlled environment feeding barn gained 0.18 lb/day more and required 0.5 lb of feed per pound of gain less than comparable steers housed in an open-front shed. These differences would be significant at $P<0.09$.

Disposal of liquid manure—No difficulties were experienced in handling the liquid manure stored over winter in pits under a slotted floor. However, a heavy concentration of H_2S gas was released when the solidified surface on each pit was broken and during the period of agitation when the material in the pit was being churned into a semiliquid sludge. Concentration of the gas exceeded safe limits. Therefore, great care had to be exercised to ensure safety of personnel and animals during the clean-out operation.

Swine

Response to selection—The effect of selection for rapid growth from weaning to market weight is being studied in the Lacombe breed and in the performance of Lacombe × Yorkshire crossbred progeny. After four generations, the average daily gain increased slightly in the selected population.

Importance of performance in sire selection—Yorkshire boars selected for minimum backfat averaged 0.53 inch less backfat than boars selected for maximum backfat. When boars of these two types were mated to Lacombe gilts, the crossbred progeny of low-backfat boars averaged 0.02 inch less backfat, 0.13 sq inch more loin eye, and 1.94% more lean in the ham face than contemporaries sired by high-backfat boars. There were no differences in the average carcass grades of pigs sired by the two types of boar.

Relationship of age and semen production—Semen was collected from Yorkshire and Lacombe boars at 72-hr intervals during five 8-week periods beginning at 9 and terminating at 28 months of age.

Volume of ejaculate, volume of gel, sperm concentration, total sperm per ejaculate, and percentage of motile sperm reached maximum values at about 18 months of age. At that age, the average output was 66×10^9 sperm per ejaculate. These semen characteristics remained fairly constant between 18 and 28 months of age.

Effect of low temperature on semen characteristics in boars—Semen from boars kept outside during the winter was compared with semen from boars housed in a heated piggery (18 C). For shelter the outside pens had single-boarded cabins with floors and bedded with straw. There were no significant differences in total volume, sperm concentration, total sperm per ejaculate, percentage of motile sperm, and amount of gelatinous material. Outside temperatures during the period averaged —24 C and were recorded as low as —40 C. Boars housed outside showed greater sex drive, but required about 3 lb more feed per day to maintain condition.

Duration of spermatogenesis in boars—Autoradiographs prepared from testes removed at intervals from mature boars injected with tritiated thymidine showed that the most mature germ cells incorporating the injected isotope were primary spermatocytes in the late preleptotene stage of meiosis. Labeled thymidine could be detected in spermatozoa leaving the testes 25 days later. This represented 2.9 cycles of the semeniferous epithelium so that one cycle was 8.6 days. If, as the literature reports, for other species studied, spermatogenesis covers four cycles of the semeniferous epithelium, the duration of spermatogenesis would be 34.4 days. Epididymal transit time for spermatozoa varied from 9 to 12 days. In the same study life-spans for various cells were 12.3 days for primary spermatocytes, 0.4 day for secondary spermatocytes, 6.3 days for spermatids with round nuclei, 1.5 for spermatids with elongated nuclei, and 6.2 days for spermatozoa.

Ovulation rates in gilts—In studies on ovulation rates in gilts there was no change in the number of ova released in the first, second, or third postpubertal estrus. Yorkshire gilts averaged 12.2 and Lacombe gilts 14.4 ova at each estrus.

Postweaning return to estrus—Within 7 days of weaning their first litters 66% of 141 sows were observed in estrus. Among Yorkshires 88% of the sows returned to estrus within 1 week compared with 41% of the Lacombe sows. The remainder of the Yorkshire sows and 51% of the Lacombes returned to estrus between 1 and 6 weeks after weaning. The average interval between weaning their litters and estrus was 5.9 days for Yorkshires and 15.4 days for Lacombes. Ovulation rates, which were similar in both breeds, were 16.1, 17.6, and 17.9 ova at the first, second, and third postweaning estrus.

Embryonic losses in sows during their second pregnancy—Embryonic losses accounted for approximately 30% of ova fertilized in Yorkshire and Lacombe sows during their second pregnancy. Almost all of these losses occurred in the first half of gestation.

Factors influencing meat quality in pigs—Preliminary studies on subjective scores for color, texture, and marbling of the *longissimus dorsi* muscle in market pigs showed that pork from Yorkshires is darker in color, firmer in texture, and has a greater degree of marbling than pork from Lacombes. Crosses of the two breeds tended to be intermediate. Relationships between vertebral measurements and area of loin eye are being studied.

Poultry

Selection in two environments—Early indications are that selection of White Leghorns for egg production may be more effective, when the pullets are reared on restricted feeding than when they are reared on full feed. After two generations of selection, pullets from birds selected under both environments performed equally well when reared in a full-fed environment. However, when the rearing environments were 30% feed restriction or the feeding of a growing mash diluted with 50% straw, the birds selected under restricted feeding surpassed those selected under full feeding in egg production and several other traits of economic importance.

Testing strains of White Leghorns—The laying performance of six strains of White Leghorns, including some top commercial

strains, was compared. One commercial strain was superior to the others. When the laying ration was provided in two forms, as crumbles and as mash, the average performance after 26 weeks was the same, but there is a possibility of a genotype–environment interaction.

Inbreeding and the effectiveness of selection for egg production—In most strains of poultry the response to conventional methods of selection has become slight in apparent genetic variability and the intensity of selection. A new cooperative project has been started to develop methods of increasing genetic variability and the rate of improvement for egg production through recurrent cycles of selection among inbred sublines. The initial crosses of sublines of 25% inbreeding are being compared with crosses of similar noninbred and sublines. Interim results show little difference in most traits because of the type of cross. However, laying-house mortality and hen-housed egg production showed a slight advantage for the crosses from selected inbred lines.

Forced molting of White Leghorns—Several strains of White Leghorns were put through a forced molt at 500 days of age to determine the economy of maintaining birds for more than 1 year's production. In only one strain were there indications that the practice might be profitable.

Apiculture

Wintering queens in nursery cages—Attempts to overwinter several queens in a single colony proved unsuccessful. Three normal colonies had their queens removed, and frames, each containing 10 queens, were placed in each colony. There was some variation in the size of cage used, but only one out of 30 queens survived over winter.

Strain testing—Four groups headed by hybrid queens of different strains were compared with two other groups headed by queens of Caucasian and Italian races. There was considerable variation in the number of bees per colony in the different races and strains. The colonies headed by hybrid queens tended to produce higher yields of honey than those headed by queens of the Caucasian and Italian races.

PLANT SCIENCE

Cereal Crops

Malting barley improvement—A new variety of malting barley was licensed. The variety named Paragon is the seventh of a series of improved barley varieties developed at this station.

Paragon has the same pedigree as Conquest except for one additional cross with Parkland. It is adapted to the Park belt of Western Canada where it has outyielded Parkland and Conquest. In Manitoba, it has also outyielded the feed varieties Keystone and Galt. Like Conquest, Paragon is resistant to stem rust and loose smut. It is rated as having excellent malting and brewing characteristics.

The new variety is six-rowed and smooth awned. It matures 4 days later than Conquest and 2 days later than Parkland. The straw is shorter and about equal in strength. In the field, it resembles Parkland, but the heads are somewhat less nodding.

Breeding for earlier maturity and shorter straw is being stressed. Numerous lines that mature 2 or 3 days earlier than Conquest and are several inches shorter are being screened for quality. The best of these will be entered in preliminary yield tests in 1968.

Feed barley breeding—Emphasis is on yielding ability, resistance to loose smut and leaf and stem rust, and resistance to leaf-spotting diseases such as spot blotch. Crosses between high-yielding Canadian varieties and specific North Dakota lines and selections exhibiting high yields and good disease tolerance are being evaluated and subjected to selection in the field. Most of the material is still in an early generation stage.

Forage Crops

Bromegrass breeding—Evaluation of bromegrass progeny for spring vigor, fall growth, and hay yield was most effective in the second year after establishment, and only a slight increase in information was attained with the inclusion of third-year data. In the evaluation of these traits, age of stand was more important than seasonal conditions. In evaluating bromegrass for hay yield and agronomic characters, spring applications of fertilizer or growing mixtures with alfalfa did not affect the ranking of bromegrass strains. However, when grown with alfalfa, the legume tended to mask the grass component and it was more difficult to evaluate the bromegrass in most agronomic characters.

Sweet clover breeding—Strains of sweet clover resistant to the sweetclover weevil, *Sitona cylindricollis* Fåhr., have been identified. Crosses between these and commercially important strains have not been successful. Analyses showed some differences in the chemical composition of resistant and susceptible strains and these differences are being investigated.

Horticulture

Pea breeding—The correlation of water-absorbing capacity of pea seed with sugar content makes it possible to select seeds that carry the double wrinkled gene before growing the F_2 generation. Seeds of F_1 plants resulting from a double wrinkled × classical wrinkled cross showed a range in absorption index that exceeded the combined ranges of both parents.

Geum—Hybrids produced in a series of crosses between attractive cultivars and native Geums have been mainly sterile. One, or possibly two, new species derived by colchicine treatment of hybrids resulted in higher chromosome counts than previously reported for the species. Winter-hardiness appears to show a good degree of dominance in four species. Some partially fertile selections from complex crosses have excellent quality blooms.

Monarda—Segregation among seedlings derived from *M. didyma* × *M. menthaefolia* produced many plant types with flowers ranging from various shades of red and purple to white. Tetraploid selections with large leaves and flowers were crossed with diploids. The resulting triploid lines were sterile, but flowered over an extended period. One of these is available for distribution to propagators, under the name "Wawanesa." This is a hardy, vigorous plant, which grows to 2–3 ft high and bears many large, deep purplish-red flowers (7.5RP 3/9 Nickerson) from July 15 to mid-August.

Chrysanthemums—Two new varieties were named and are available for distribution to propagators. Maud Brandon plants are 2 ft high; strong reddish-purple (2.5RP 5/10 Nickerson) flowers 2 inches in diameter, 3/4 double, are borne in profusion in early September. Vicky Brandon plants are vigorous, about 30 inches high and have large, double, yellow flowers of good quality borne in mid-September.

Salix—Two selections of willow were named and made available for distribution. Both are native species and can be propagated from hardwood cuttings. *S. maccalliana* 'Brand', selected for the reddish-brown color of its winter bark, was obtained near Brandon. *S. lutea* 'Carberry', selected for the dark-yellow color of its winter bark, was collected near Carberry.

SOILS AND AGRONOMY

Soil Fertility

Forage mixtures improve soil fertility—When forage crops were grown for a period of years on a Miniota sandy loam, and then incorporated in the soil, there was a progressive increase in nitrate N. The actual increase was dependent on the forage grown and the cropping sequence.

Phosphorus—In studies designed to determine the response of flax to various rates and methods of placement of phosphatic fertilizers, preliminary results indicate that flax responds to phosphorus on noncalcareous soils which are low in $NaHCO_3$ extractable phosphorus.

Broadcast applications of phosphatic fertilizer at high rates have shown some

residual effect of this element on a subsequent crop of wheat.

Nitrogen—Where soil is low in nitrate N and in exchangeable K, the K requirements of flax and barley crops have to be satisfied before a response is obtained from added N.

Potassium—Flax and barley have responded to K fertilizer broadcast after seeding on soils where the levels of exchangeable K were low. However, rates of 20 and 30 lb/acre of K_2O applied with flax and barley seed respectively caused yield depression due to germination damage.

Microelements—Studies on the effect of application of copper on yields of barley and forage crops showed that barley on coarse-textured calcareous soils responds to copper broadcast at rates up to 10 lb/acre.

Soil Management

Management of saline soil—Adequate fertilization combined with minimum tillage resulted in increased yields of grain and forage in the Pasquia drainage project in northern Manitoba. The mean conductance of soil decreased primarily in the surface 4 inches in the period from 1960 to 1963. In the subsequent 3 years further decrease in conductance occurred in the 4- to 8-inch and 8- to 12-inch levels.

Rotations—Summerfallow substitutes including sweet clover, flax, and intertilled crops are being studied in 3-year rotations. All harvest residues are returned to the soil and fertilizer is added on the basis of a soil test to satisfy the requirement for maximum production of specific crops. After 3 years, fall levels of nitrates and phosphates continued to increase.

Cultural practices—The effects of date of seeding and fertilizer applications on barley and wheat grown on summerfallow and stubble are under investigation. In both crops, the response to fertilizer was greater with early seeding than with late seeding. Wheat yielded 81.2% of barley on fallow compared with 88.3% of barley on stubble. The performance of both crops was superior on summerfallow. The yield of barley on stubble was 59.0% that of barley on fallow, whereas the wheat yield on stubble was 63.7% that of wheat on fallow.

Weed Control

Nitrogen fertilizers and herbicides applied on barley and wheat—Pre- and postemergence applications of liquid N at 20 and 40 lb/acre produced similar yield increases in Conquest barley. Herbicides recommended for weed control and mixed with the liquid N at rates up to 20 lb/acre gave good results when applied at the 3- to 4-leaf stage. Liquid and granular N applied at 10–80 lb/acre to Manitou wheat produced similar yields. However, there was significantly more green foxtail, *Setaria viridis* (L.) Beauv., on plots where the granular N was used.

Control of wild oats in wheat—Triallate at 1 lb/acre harrowed into the soil in late fall gave 91% control of wild oats in the subsequent crop of Manitou wheat. Fall treatment gave 9% better control than postseeding treatment in the spring. Plots that were treated in the fall or spring outyielded untreated plots by 26% (4.7 bu/acre).

Broad-leaved weeds in barley—Good control of broad-leaved weeds and green foxtail in barley was obtained with TCA at 1 lb/acre, and MCPA or 2,4-D amine at 8 oz/acre. Weed infestations were light and growth was restricted by drought so that there was no significant difference in yield due to herbicidal treatment.

Weed control in corn—Harrowing corn before and after emergence followed by two interrow cultivations gave good control of green foxtail. Yields of corn in tons of dry matter per acre were 3.03 for hand-weeded plots, 2.89 for preemergence and postemergence harrowing and two cultivations, 2.74 for two interrow cultivations, and 2.17 where no control measures were applied.

Weed control in potatoes—A heavy infestation of green foxtail was controlled by harrowing potatoes before and after emergence followed by two or more interrow cultivations as necessary. Yields were 104 cwt/acre for hand-weeded plots, 92 cwt/acre for harrowed and cultivated plots, and 22 cwt/acre for plots cultivated twice without harrowing compared with 13 cwt/acre for untreated plots.

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Research Station
Morden, Manitoba

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[1] On educational leave.
[2] Appointed June 1, 1967.

INTRODUCTION

This report summarizes the significant results of our 1967 research.

The Research Station is in south central Manitoba, 14 miles north of the Canada – United States border and 35 miles west of the Red River. A substation is operated at Portage la Prairie, 60 miles north of Morden. The Station emphasizes breeding programs to produce varieties in special and horticultural crops, which are adapted to the Prairie Provinces. Improvements in weed control and crop management are important objectives as well. The professional staff welcomes exchange of information with anyone of mutual interests, either by personal visits to the Station or by correspondence.

Eric D. Putt
Director

VEGETABLES

Tomato Breeding

Tomatoes with the crimson, *cr*, and high pigment, *hp*, fruit color genes are adapted for harvesting when they are mature green and then ripening in dark storage. To select in hybrid populations for intense red pigmentation, the red, *a*, and the yellow, *b*, color factors were measured with a Hunterlab color meter and were expressed by the $a/2.5\ b$ color index. An index of 0.75 was standard for comparison. The Morden strain 64T20 and several selections from the cross 64T20 × Crimson HC25 gave high indices, from 0.92 to 0.96. These high values, compared with the varieties Pyramid Crimson, index 0.81, and the standard red-colored Early Giant, index 0.72, may be attributed in part to the interaction of the *cr* and *hp* genes. Transgressive segregation was shown by the results. Varieties that gave high indices when ripened in the field did not always show equally high values when ripened in the dark. There were significant differences among some varieties. Skin color contributed much to the visual appeal of tomatoes with crimson-colored flesh. A strain with colorless skin had a crimson flesh color index of 0.89, but it lacked the visual appeal of fruits of a strain with yellow skin, which had a crimson flesh color index of 0.81.

Malformation of Flowers in Tomato

Frequently the first flower of the primary cluster of tomato plants is malformed and the resulting misshapen fruit has little economic value. The condition occurred when young plants were subjected to a temperature of 40 F. The malformation increased in severity as the exposure to low temperature was lengthened, and the stems of the plants developed fasciation. Other plants, grown with limited moisture to cause wilting, and at a temperature of 75 F, showed even greater malformation of the flowers, but fairly little fasciation. Therefore, factors such as water stress may cause malformed flowers independently of fasciation. Spraying young plants grown at 40 F with Alar, *N*-dimethyl amino succinamic acid, a chemical that retards cell division and cell elongation, at the rate of 10 ppm resulted in significantly less malformation of the first flower and less fasciation of the stem than in the check plants.

Chipping Quality in Potatoes

In a 3-year study, potato chips from the seedling F5889 exceeded in quality those from the variety Kennebec. The superior quality appeared in all samples from weekly harvests, which started when the first tubers were 1 inch in diameter and which continued until late fall, and it persisted in the mature tubers during storage at different temperatures. This selection also fluctuated less than Kennebec during changes of temperature in the field; for example, in 1966 in a 4-week period when the temperature of the soil dropped from 63 to 49 F, the Hunterlab L values of the chips dropped from 62

to 61, whereas the decline for Kennebec was from 59 to 47.

The protein content of the two varieties was studied in 1967. They differed in protein content, and changes in relative amounts of protein occurred during storage. After 12 weeks of storage at 38 to 50 F, the seedling F5889 had 0.4 mg and Kennebec had 0.8 mg of protein/g fresh weight. Ten weeks later the protein content of F5889 had increased to 2.8 mg when stored at 50 F, and 2.9 mg/g at 70 F. Comparable values for Kennebec were 2.1 mg and 2.2 mg/g.

Plant Spacings of Dwarf Cabbage

To study the productive ability and head size of the dwarf varieties Pee Wee and Little Leaguer, the two varieties were grown for two seasons in replicated plots in a 6-inch and a 12-inch grid (174,240 and 43,560 plants/acre respectively) and in a conventional planting of rows 36 inches apart and plants 15 inches apart in the rows. Golden Acre, a standard variety, was included only in the conventional planting. Both dwarf varieties yielded most in the 6-inch grid, but they produced smaller heads than in the 36-inch rows. Pee Wee yielded less at all spacings than Golden Acre in the conventional planting, but Little Leaguer, in the 6-inch grid, significantly outyielded Golden Acre. Heads of normal size, or 8 oz for Pee Wee and 13 oz for Little Leaguer, were obtained when the spacing was increased from the 6-inch to the 12-inch grid. Little Leaguer in the 6-inch grid produced heads weighing 8 oz.

Effect of Plant Populations on Pickling Cucumbers

Populations of 39,000 plants/acre, with 6 inches of irrigation water applied at three different times in addition to the natural precipitation of 4.43 inches during June, July, and August, produced 4.44 tons/acre of marketable cucumbers. Populations of 19,000 and 77,000 plants produced 3.95 and 3.69 tons/acre. Yields from nonirrigated plots varied from 1.70 to 2.93 tons/acre. The irrigated plots produced over 75% marketable fruits compared with 60% in the nonirrigated plots. The yields were determined from plots of 90 sq ft replicated four times.

Effects of Two Sources of Nitrogen on Sweet Corn

On a fine, sandy loam soil 80 lb/acre of N increased the yield of sweet corn 29% over the check. Total yield of canning ears, husked and dry ear weight, dry kernel weight, and ear length and ear tip fill did not differ when urea or anhydrous ammonia were used as the source of N for an application of 80 lb/acre at seeding plus side dressings of 25 lb at 12–18 inches high and a further 25 lb at tasseling. The side dressings stimulated vegetative growth, but depressed yield.

Effect of CO_2 in Radishes

An atmosphere enriched with CO_2 hastened root development in the variety Cherry Belle and increased the yield by 25 to 60% while maintaining high quality. The concentration of CO_2 was maintained at 2000–2200 ppm during the day and it was 400–500 ppm in the controls. The enrichment with CO_2 was most beneficial at a temperature of 75 F during the day. At 65–68 F the difference between the yields in CO_2 and the control was much less but still significant at $P = 0.05$.

ORNAMENTALS AND FRUIT CROPS

Progress in Developing Clonal Apple Rootstocks

Twenty-seven apple rootstock clones were selected for final test. All clones were readily propagated by stooling or from softwood cuttings under intermittent mist. No root injury was found on any of the selections, although they were grown where the roots were exposed to low temperatures. Seventeen of the selections were chosen for good bark thickness of the roots. The percentage of root to bark

ranged from 50 to 62%, which shows dwarfing effects similar to that of semi-vigorous rootstock types. Three clones were found to be highly resistant to lime-induced chlorosis, which is common to prairie soils. Susceptible varieties are being grafted on the three clones to determine if chlorosis can be prevented with a resistant rootstock. Seven other easily propagated, red-leaved clones were included in the evaluation. Red leaf color is useful in identifying the rootstock and scion after grafting.

The Prairie Cooperative Fruit Breeding Project

Most of the selection has been completed in the seedling blocks, which were planted at several points in the Prairie Provinces. Thirty-nine selections were advanced for regional trials at Brooks, Melfort, and Morden. Of these, 16 will be planted in 1968, and the remainder propagated for planting in 1969 and 1970. The fruit of the selections ranged from 2 to 3 inches in diameter, and color and quality were good. The station of origin and the number of selections were: Horticultural Station, Brooks, Alta., 14; Research Stations, Lacombe, Alta., 6; Melfort, Sask., 1; Scott, Sask., 2; Morden, Man., 4; University of Saskatchewan, Saskatoon, 4; and University of Alberta, Edmonton, 8.

Effect of CO_2 on Propagating Ornamentals

Atmosphere maintained at 2,000 ppm of CO_2 during daylight hours promoted rooting of *Chrysanthemum, Weigela,* and *Potentilla fruticosa* L. Cuttings rooted in the CO_2-enriched atmosphere had more roots per cutting and had a better rooting percentage than those from the control. All cuttings were dipped in 3-indole butyric acid. Chrysanthemum cuttings received a concentration of 1,000 ppm and the weigela and potentilla cuttings received 3,000 ppm.

Seedlings of dahlias, chrysanthemums, and marigolds grown in the CO_2-enriched atmosphere were in prime condition for field setting 2 weeks sooner than those grown without additional CO_2. The roots were two to three times larger in the CO_2 than in the control.

Breeding Woody Ornamentals

The woody ornamentals breeding project resulted in the naming and release of one new cultivar. A creeping juniper, which has been on test at Morden for over 35 years, has been officially described.

Crataegus mordenensis Boom cv. Snowbird is a second-generation open-pollinated seedling of *Crataegus mordenensis* 'Toba', with double, white flowers. The tree or large shrub is upright in habit and is hardier than its female parent. The glossy, dark-green leaves vary from lobed to almost entire, with serrated edges. The roundish (1 cm in diameter), bright-crimson fruit is produced sparingly. The leaves of Snowbird hawthorn are more like those of *Crataegus succulenta* Lk., which was the male parent of Toba hawthorn. The female parent of Toba was a double, pink-flowered form of *Crataegus oxyacantha* L., which has deeply lobed leaves. The original cross was made by W. L. Kerr at Morden. The cultivar Toba, introduced in 1949, was the only seedling named from over 200 first-generation seedlings. In 1959, B. K. Boom, Wageningen, Holland, described the hybrid species *Crataegus mordenensis* and cited 'Toba' as the type for the species.

Juniperus horizontalis Moench cv. Prince of Wales is very procumbent and forms a dense mat 4 to 6 inches high. In the arboretum at Morden, the foliage on 18-year-old plants is medium, bright green and both acicular (juvenile form) and scalelike (adult form). During the late fall and winter exposed leaves are purple-tinged. The juniper is a permanent and very attractive ground cover. It was found growing, among others of the species, along Pekisko Creek on the property of the E. P. Ranch near High River, Alta., by the late Wellesley White, a cattle breeder and farmer of the Morden district. In 1931, Mr. White collected rooted branch layers for Dr. W. R. Leslie, the Superintendent of the Experimental Farm here at that time. The juniper was originally named Prince of Wales, and this name remains today.

Evaluation of Prairie Chrysanthemum Cultivars

One hundred and thirty-seven cultivars and selections of chrysanthemums from breeders on the prairies were collected at Morden in the spring of 1966, and propagated in the winter of 1966–67. Five plants of each were observed in 1967. The test emphasized the localized adaptation of chrysanthemum cultivars. Those from Lethbridge, Alta., and North Platte, Neb., flowered later than those developed at Brandon, Dropmore, Morden, and Winnipeg, Man.; and Saskatoon, Sask. In a second-year test, 10 out of 15 cultivars from Lethbridge failed to overwinter and only 10% of those from Nebraska survived. The best cultivars, rated for profusion of bloom, plant habit, and general adaptability for garden decoration, included the Morden introductions 'Cameo', 'Canary', 'Tupper', 'Brown', and 'MacDonald' with double flowers; and two compact-growing cultivars 'McGee' and 'Howe' with single flowers. Well-rated cultivars from other stations were 'Aztec', 'Wayzata', 'Page's Gold', 'Bonnie Brandon', 'Jocelyn Brandon', and 'Harvest Bronze'. Two large-flowered cultivars from Nebraska, 'Stadium Queen' and 'Nebraska Centennial', attracted considerable attention. A few flowers of 'Stadium Queen' were open when a temperature of 25 F at Morden severely damaged the plants on October 11. 'Nebraska Centennial' started to bloom in early September and continued for 5 weeks.

SPECIAL CROPS

Buckwheat

In 2 years of testing at Morden, the selection CD 7274, from the Ottawa Research Station, has yielded 29% more than the standard variety Tokyo. The seed size and time required to mature are similar to Tokyo.

Tests with two varieties at seeding rates of 0.5, 1, and 2 bu/acre in rows 6, 12, and 18 inches apart, at two sites, showed that the best combination was 0.5 bu/acre in rows 6 inches apart.

Corn Breeding

Early maturing forms of inbreds B8, B14, and WF9 were selected from crosses that included these central corn-belt lines as the recurrent parents in backcrossing programs. The recovered lines resembled the recurrent parent surprisingly well in both plant and ear characteristics. Silking in these lines compared with the early inbred V3 varied from a day earlier to 8 days later.

Corn Population Studies

Five hybrids were each grown at 30,000, 24,000, 18,000, and 12,000 plants/acre in rows spaced 20, 26, 32, and 38 inches apart. As in 1966, row spacing did not affect grain yield significantly. The highest yields were obtained from the population of 30,000 plants/acre. However, the yields at this population exceeded the 24,000 population by only 2.5 bu/acre. This shows that maximum production was reached with the high populations. The number of barren plants increased significantly with the increase in plant population. Hybrids did not respond similarly to the increase in plant population, but the differences in response were not as marked as in 1966. The increases of the high populations over the low populations ranged from 22 to 33 bu/acre.

Flax Breeding

F.P. 454, a selection from the cross Valuta × Raja, continued to be one of the highest yielding entries in the Cooperative Test. It is similar to Redwood 65 in maturity and oil content, but is slightly higher in yield.

Seed of 96 Marine backcross lines, each homozygous for one of the genes for immunity to rust, L^6, M^3, N^1, and P^3, was increased in California. Tests showed that approximately 25% of the lines significantly exceeded Marine in yield and most of the others equaled Marine.

At Morden and Portage la Prairie, the early maturing variety, Noralta, significantly outyielded Redwing, Raja, and Redwood in four of five weekly seeding dates. In the first date, sown as soon as field conditions permitted, both Redwing and Redwood exceeded Noralta.

Flax Rust

For the first year since 1962, when race 300 of flax rust, *Melampsora lini* (Ehrenb.) Lév., was discovered in Manitoba, no rust was found in Manitoba or Saskatchewan. The absence of rust is ascribed to the shift to resistant varieties and the dry weather in spring and early summer.

Field Peas

The selection M.P. 39, from the cross Chancellor × Weibulls' 700, outyielded Century and Chancellor by 6% and 13% in the Western Cooperative Test. M.P. 41, from the same cross, exceeded Chancellor by 8%. Both selections are similar to Chancellor in seed size and cooking quality, but M.P. 39 is 3 days later than Chancellor. The blue-green selections, M.P. 21 and M.P. 46, also from the cross Chancellor × Weibulls' 700, yielded 27% and 28% more than the standard variety Delwiche Scotch Green.

Evaluation of introductions for resistance to *Mycosphaerella pinodes* (Berk. & Blox.) Vestergr. has continued. Of the 1,200 items from the USDA world collection, 95 that showed some resistance were retested and 30 individual plants were chosen from them for further evaluation. A permanent disease nursery was established.

Soybean Breeding

Strain CM30 in a three-test average in Manitoba again performed well. It exceeded Altona by 11.0% in yield, and matured earlier. Strain CM21, for the second year, performed well; it exceeded Portage by 19% in yield, and matured in the same time. A new selection, CM84, exceeded Portage by 26% in yield.

Soybean Population Studies

Four strains were grown at two populations of 350,000 and 175,000 plants/acre at each of the row spacings 12, 24, and 36 inches. The 12-inch row spacing outyielded the 24- and 36-inch spacings by 2 and 14%. On the average, in all row spacings the two populations gave identical yields. This shows that the standard seeding practice of about 175,000 plants/acre is satisfactory. Varieties reacted similarly to different row spacings and populations. The narrower rows produced shorter plants.

Sunflower Breeding and Genetics

The hybrid CM90RR × Peredovik has outyielded all other entries in tests across Canada for 3 years. Its oil content is lower than that of Peredovik, but it produces more oil per acre. It matures slightly later than Peredovik. In a field-scale crossing block of 1.5 acres, seed containing 60–70% hybrids was harvested from the partially sterile female (CM90RR). Phosphorus fertilizer was applied to the female rows and, as a result, they reached peak flowering 2 days before Peredovik. Higher percentages of hybrids should be obtainable from field-scale crossing blocks by treating both parents alike and thereby improving the coincidence of flowering of the two parents. The hybrid CM323 × Peredovik, which possesses very high oil content, outyielded Armavirec and Peredovik for two seasons. Its maturity is similar to Peredovik. In early tests other experimental hybrids produced up to 45% more seed than Peredovik. A new Russian variety, Krasnodarec, was tested for the first year. It was similar in maturity and appearance to Armavirec, but yielded more. It is also expected to exceed Armavirec in oil content.

A single-gene male sterile stock has been received from France. It is similar to another male sterile stock identified earlier at Morden, but the recessive gene controlling it is closely linked to the recessive character *t* (green hypocotyl). Therefore, properly constituted, a line can be maintained by sibpollination so that half the plants will be green, male sterile and the other half red, male fertile. In a crossing block the fertile red plants

could be removed easily, and the harvest from the remaining plants would be virtually 100% hybrid seed.

Sunflower Row Spacings

Three years of testing show that the early maturing variety Armavirec yielded about half as much in rows 12 ft apart as in rows 3 ft apart, whereas Peredovik, a later maturing variety, yielded slightly less than half as much. In 12-ft rows the best plant density for Armavirec was four plants per ft of row and for Peredovik three plants. Increased plant density hastened maturity by 3–4 days. Peredovik lodged more than Armavirec at high plant densities.

In 1967, rows spaced 1 ft apart compared to 3 ft apart increased the yield of Armavirec and Peredovik by 16 and 20%. For 3 years results have shown a consistent advantage for the 1-ft rows.

Sunflower Diseases

Resistance to verticillium wilt was found in 23 out of 25 collections of wild sunflower, mostly *Helianthus annuus* L., tested in a field heavily infested with the disease organism. The collections were obtained over an area from Western Canada to the southern United States, and from Argentina. The results show that resistance is less frequent in collections from Canada and the northern United States than from other regions.

Twenty-three crops and varieties were planted in the disease nursery mentioned above, and reisolation of the pathogen from underground parts was attempted. Only sunflower became diseased and the organism was abundantly present. It definitely occurred on flax, garden peas, mustard, potatoes, and safflower. From the same field *Verticillium nigrescens* Pethybridge was isolated from apparently healthy tomatoes. An unidentified species of *Verticillium* forming brown mycelium in culture but different from *V. albo-atrum* Reinke & Berth. was abundantly present on stem bases and roots of potato and was also carried inside tubers. The same unidentified *Verticillium* sp. or more likely *V. dahliae* Kleb. occurred on buckwheat, cotton, eggplant, field pea, pepper, rape, soybean, and tomato. No *Verticillium* was observed on alfalfa, apple, corn, plum, raspberry, strawberry, and sugarbeet.

Sunflower, potato, and tomato were inoculated with strains of three *Verticillium* spp. *V. dahliae* from sunflower in Manitoba caused severe disease only in sunflower, very light disease in potato, and none in tomato. *V. dahliae* from tomato and *V. nigrescens* from sugarbeet, both from Quebec, and *V. albo-atrum* from potato in Manitoba and North Dakota caused moderate or severe disease in potato and tomato but none in sunflower. All strains were reisolated from the underground parts of all three crops.

Inoculation experiments suggest that the resistance of inbred CM54 to *V. dahliae* is located in the root and less so in the stem, whereas that of CM144 is located in both root and stem. High concentrations of inoculum overcame the resistance of CM54 but not that of CM144.

A third gene, R_3, for resistance to rust, *Puccinia helianthi* Schw., has been demonstrated in inbred selection 403-4. It is nonallelic to R_1 and R_2, previously reported in sources 22 and 88.

WEED CONTROL

Some herbicides show promise for selective weed control in seeded onions grown without irrigation. Linuron and prometryne applied to seedling broad-leaved weeds in onions just past flag leaf to two-leaf stage caused only minor crop injury at rates adequate for satisfactory weed control. Low-pressure spraying with nitrofen[3] (2,4-dichlorophenyl-4-nitrophenyl ether) was effective on some of the common broad-leaved weeds and caused only minor crop injury, but it failed to control

[3] Rohm and Haas Co. of Canada Ltd.

purslane or green foxtail. Further testing of this herbicide is needed. The experimental herbicide benzadox[4] (benzamidooxyacetic acid) showed promise for control of green foxtail in onions.

Sunflowers tolerated preplanting soil-incorporated treatments of EPTC[5] (ethyl *N,N*-dipropylthiocarbamate) at 3.5 lb/acre and trifluralin at 1 lb/acre with no reductions in yield, under nearly weed-free conditions.

[4] Spencer Chemical Division of Gulf Oil Corp.
[5] Stauffer Chemical Co. of Canada Ltd.

Late fall application of diphenamid in strawberries at 6 lb/acre, just before mulching, gave almost complete control of volunteer grain from the mulch and good early season control of weeds in the following year.

A study is in progress to examine the residues in the soil that result from repeated application of some herbicides. Early results show that atrazine and picloram are decomposed quite slowly in southern Manitoba and in the system of soil management used in this test.

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Departures

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[6] Appointed May 1967.
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[10] Appointed September 1967.
[11] Appointed November 1967.

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Egyptian Government Scholarship — Breeding wheat for rust resistance

N. Iordanou, B.Sc.
Commonwealth Scholar — Effect of temperatures on insecticides used for the control of stored-product insects

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INTRODUCTION

The functions of the Research Station, Winnipeg, are: to develop varieties of wheat, oats, and barley suitable for production in the Prairie Provinces; to devise protective measures against diseases and insects for the growing plants and the stored and milled products from these crops; to conduct soil surveys and related research in Manitoba; and to provide quality (milling, baking, malting, feeding energy) screening services for cereal-breeding programs.

This report outlines the results of the 1967 research. None of the research is described in detail. In some cases, as with long-term projects, progress is outlined. The barley breeding and genetic projects were modified and more emphasis has been placed on the breeding of two-rowed barley. In the quality aspects, greater emphasis is being given to selecting for higher energy in both barley and oats.

A. E. Hannah
Director

BREEDING, GENETICS, AND CYTOGENETICS

Plant-breeding Methods

The objective is to develop and evaluate plant-breeding methods for self-pollinated species with particular emphasis on characters such as yield which are inherited in a complex manner.

A computer-simulation technique was used to investigate the feasibility of random mating in self-pollinated species. It was found that crossing among a relatively small number of individuals (as few as 30 pairs) would suffice in controlling sampling variability to the degree that the theoretical effects of random mating would be realized. At the same time, it was pointed out that the desirable effects of random mating would not likely be realized unless some form of recurrent selection is practiced.

Yield data from oat trials were used together with a theoretical study to show that the use of "control" plots in yield trials was of questionable value.

The magnitudes of the various genotype by environment interaction variances were calculated from 10 years' data for yield

of wheat, oats, and barley in Western Canadian Cooperative Test trials. These results differed from those reported by workers in other countries, and indicate the need for more research into genotype by environment interaction in the prairie region.

Barley Breeding and Genetics

A full-time program to develop disease-resistant two-rowed varieties of barley for the eastern prairies was started in 1967. Many two-rowed introductions (particularly European) have a high yield potential, but their susceptibility to prevalent diseases makes them unsuitable for production in this region. Crosses have been made to develop two-rowed varieties resistant to stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Erikss. & Henn.), net blotch (*Pyrenophora teres* (Died.) Drechsl.), and loose smut (*Ustilago nuda* (Jens.) Rostr.).

A two-rowed variety, Gospeck C.I. 9094, from the International Barley Disease Nursery was observed to be highly resistant to stem rust. Gospeck was crossed with Herta, a two-rowed variety susceptible to stem rust, and with Conquest, a six-rowed variety resistant to stem rust, in order to study the inheritance of the Gospeck resistance gene(s) and to determine whether it is the same as the Peatland ("T") gene.

Six-rowed selections possessing resistance to stem rust, and to net blotch or septoria leaf blotch (*Septoria passerinii* Sacc.) or both, have performed well in yield trials, and several have promising malting quality. Two lines from the cross C.I. 5791 × Parkland with resistance to stem rust and net blotch were retained in the Western Cooperative Barley Test for the 3rd year. Both have been high yielding in Manitoba and Saskatchewan and possess above-average straw strength. One of these lines is now undergoing its second pilot malting and brewing test.

The genetic behavior of the malting characteristics, extract yield, saccharifying activity, nitrogen, and 1,000-kernel weight, and the correlations among these characteristics, were examined in F_3 populations from crosses between Manchurian and non-Manchurian barley varieties. Quality expression was found to be influenced by unfixable variation—dominance or epistatic effects, or both—presumably introduced into the populations from the Manchurian parents. Positive correlations were obtained between saccharifying activity, nitrogen, and 1,000-kernel weight; negative correlations were obtained between saccharifying activity and extract. The correlations between 1,000-kernel weight and extract, and nitrogen and extract, were inconsistent between crosses.

No major genetic or physiological barriers against combining disease resistance from non-Manchurian varieties with malting quality from adapted types were discovered. However, the influence of unfixable variation may necessitate postponement of selection for quality until the F_4 generation or later.

In the crosses Odessa × Pannier and Odessa × Excelsior, inheritance of reaction to *Ustilago nigra* Tapke and *U. hordei* (Pers.) Lagerh. was controlled by a single recessive gene.

Oat Breeding and Genetics

The breeding work is directed towards obtaining high-yielding oats of good nutritive value combined with resistance to stem rust (*Puccinia graminis* Pers. f. sp. *avenae* Erikss. & Henn.) and crown rust (*P. coronata* Cda. f. sp. *avenae* Erikss. & Henn.) and good strength of straw. A higher content of fat in the grain is being used as the selection factor to improve the feeding value of oats.

Two new varieties of oats were released in 1967. Kelsey, a high-yielding variety, was distributed in Manitoba and eastern Saskatchewan. The second variety, Sioux, was distributed in southwestern Saskatchewan and southern Alberta, where it has yielded very well and should replace the older variety Garry.

The search for new sources of stem rust resistance has been continued. Collections from Czechoslovakia and Russia were received and tested, but no satisfactory resistance to race C10 has been discovered.

Several new genes for resistance to crown rust were isolated from Israeli collections of *Avena sterilis* L., a hexa-

ploid wild oat, and identified in F_2 backcross lines of *A. sterilis* × Pendek[2] crosses.

Genetic studies on the variety Jostrain indicate that this variety has a single gene or two tightly linked genes conferring resistance to races of both crown rust and stem rust. This gene, designated *Pg*-3, is at the same locus as *Pg*-9, which also has been reported to confer resistance to both crown and stem rust. This type of association is unique.

In the crosses Anthony × Black Mesdag, Anthony × Camas, and Camas × Black Mesdag, inheritance of reaction to two races of *Ustilago avenae* (Pers.) Rostr. was conditioned by a single recessive gene for resistance.

Common Wheat Breeding

The hard red spring wheat variety Manitou, which was licensed in 1965, appears to be performing very well in the field and is expected to be the predominant variety on the prairies within a few years. Attributes such as awns, additional stem and leaf rust resistance, nonsensitivity to length of day, and resistance to the cereal leaf beetle are being incorporated into this variety by the backcross method. This method, although useful in producing new varieties with the desirable milling and baking characteristics of Manitou, produces the same inherent yielding ability as the recurrent parent. The pedigree method of breeding and a range of parental materials are being used to obtain higher-yielding varieties.

The development of hybrid wheats and the investigation of the associated problems continue. Adequate restoration of fertility in the F_1 plants is a major limiting factor in developing commercial hybrids. New sources of genes for restoration have been obtained—the French variety Primepi being one—and crossed with Winnipeg lines.

Durum Wheat Breeding

Advanced testing was completed on a number of relatively early maturing, short, strong-strawed lines. One of these, of excellent quality, was purified and increased in 1967 for future distribution.

Continued emphasis in the breeding program was placed on developing early, short-strawed durum wheat varieties of satisfactory yield and quality. Selection in a number of simple and complex crosses, using the pedigree method, resulted in approximately 350 lines for preliminary quality and yield testing in 1968. In addition, 80 semidwarf lines were selected from the modified backcross program involving dwarf tetraploids. Research to gain a better understanding of yield components was started. Ten selected hybrids are being used to study various aspects of yield and methods of testing in early generations.

Stem rust resistance from various sources is being incorporated into the susceptible varieties Mindum and Stewart by backcrossing. Resistance from several Ethiopian varieties and from *Agropyron elongatum* Host ex Beauv. has now been incorporated into these varieties. A backcross program to transfer resistance from *Triticum monococcum* L., an Egyptian variety (P.I. 243067), and the common wheat genes *Sr*6 and *Sr*7 to Mindum and Stewart is in progress. Single-gene lines are being established.

The final backcross has been made to transfer cytoplasmic sterility and fertility-restorer genes from *Triticum aestivum* L. to a number of durum wheat varieties as part of the program to develop hybrid durums. Fertility restoration appears to be inadequate in most lines.

Cytogenetics of Wheat

Tests on both seedlings and field-grown adult plants indicate that the stem rust resistance transferred from *Triticum monococcum* L. (R.L. 5244) to *T. durum* Desf. var. Stewart is highly effective at the tetraploid level against all races and biotypes of the 15B complex to which Stewart is susceptible. This resistance is now being transferred to the hexaploid variety Marquis.

Six synthetic hexaploid wheat varieties (AABBDD), their parental components *Aegilops squarrosa* L. (DD) and Tetra Canthatch (AABB) extracted from the common wheat Canthatch, and Canthatch were tested for seedling reaction to six races of stem rust and four races of leaf

rust. Tetra Canthatch had greater resistance than Canthatch to all races, except one, of stem rust. The D genome of Canthatch inhibited the full expression of resistance carried by the AABB component. This inhibition of resistance by the D genome was also shown when each of the four susceptible varieties of *A. squarrosa* was combined with Tetra Canthatch to produce synthetic hexaploids. These hexaploids did not retain the high resistance exhibited by the AABB component. Conversely, the high resistance to all four races of leaf rust by *A. squarrosa* (R.L. 5289) was fully expressed in the synthetic hexaploid produced from this variety and the susceptible Tetra Canthatch. Seedlings of *A. squarrosa* (R.L. 5271) were susceptible to all races of leaf rust, but the adult plants were highly resistant. The synthetic hexaploid produced from this *A. squarrosa* variety and Tetra Canthatch (susceptible in all stages) was also susceptible in the seedling stage, but resistant to moderately resistant in the adult stage. The resistance of the synthetic, therefore, was not as effective as the *A. squarrosa* parent. The reaction of hexaploid wheat to specific races of stem and leaf rust was apparently determined by the genetic interaction of its genomic components rather than by independent gene behavior. Therefore, the full resistance of the diploid or tetraploid species might not be expressed at the hexaploid level.

The possibility of extracting the AADD genomic component of common hexaploid wheat is being examined. A cross has been made between the common hexaploid variety Marquis (AABBDD) and a synthetic AADD amphiploid (*T. monococcum* × *A. squarrosa*). The resulting pentaploid (AABDD) was backcrossed to Marquis, pentaploid types being used in successive backcrosses. The pentaploid obtained after four backcrosses is completely self-sterile despite regular pairing of the homologous genomes (14″ AADD + 7′B). Unless fertility can be restored in further backcrosses to the hexaploid, it will be impossible to extract the AADD component because it can be recovered only in the progeny of the selfed pentaploid.

Genetics of Wheat

Inheritance of seedling resistance to races 15 and 161 of leaf rust of wheat was investigated in the varieties Webster, Loros, Brevit, Carina, Malakof, and Centenario. Webster has the *Lr*2 gene, which accounts for all of its resistance to the races used. Carina has an allele at the same locus, $Lr2^2$, and also a gene independent of the *Lr*2 locus, which confers a type 2 reaction to a number of races including 15 and 161. Resistance present in Loros is accounted for by another allele, $Lr2^4$. Brevit may also have this allele and the type 2 gene present in Carina. Malakof and Centenario have the *Lr*1 gene, which is independent of the *Lr*2 locus.

The susceptible parents appeared to influence the dominance of the *Lr*2 alleles. In crosses with Thatcher the alleles were either partly dominant or recessive; in crosses with Prelude and Red Bobs they were completely dominant. The expression of resistance of the *Lr*2 alleles to race 161 was also influenced by the susceptible parent. In crosses with Red Bobs one or more genes, which modified the degree of resistance to race 161, appeared to be segregating. This was not observed in crosses with Thatcher.

Stem rust resistance to race 56 of the durum varieties Mindum, Spelmar, and Arnautka was transferred to common wheat. Genetic analysis indicated that *Sr*1 or an allele of *Sr*1 was transferred. The variety Red Bobs has a gene for stem rust resistance, similar to the Marquis gene, at the *Sr*7 locus. In addition, Red Bobs has an unidentified gene for resistance to race 17A.

CEREAL RUSTS

Stem Rust of Wheat

Epidemiology—The stem rust resistance of the commercial wheat varieties produced in Western Canada continues to be effective. No stem rust was found on the varieties Pembina, Selkirk, Manitou, or Stewart 63 in the rust area of Western Canada in 1967, and the physio-

logic race survey did not disclose any races capable of attacking them. The overall pathogenicity of the races found in 1967 was less than in the previous 2 years. In 1965 and 1966 races C22(32) and C25(38) were found, but they did not occur in 1967. These races are virulent on seedlings of the varieties Selkirk, Pembina, and Manitou. They are not as virulent on adult plants of these varieties as on seedlings, but they are the most threatening races isolated in recent years. Their disappearance in 1967 means that the field resistance of Pembina, Selkirk, and Manitou is more effective than it was in the previous 2 years.

Changes in prevalence of physiologic races of wheat stem rust can result from the selection pressure of widely grown varieties. Experiments with plants in growth chambers indicated that these changes can also result from differences in aggressiveness of the parasite at various temperatures.

Leaf Rust of Wheat

Epidemiology and genetics—Genetic studies on the inheritance of resistance in the International differential varieties, and the inheritance of virulence in leaf rust on these varieties, have indicated that, as far as these varieties are concerned, the leaf rust population in Canada can be adequately differentiated by the resistance genes *Lr*1, *Lr*2, *Lr*2^4, and *Lr*3. Backcross lines containing these genes for resistance to leaf rust have been developed and were used in the 1967 leaf rust survey. Avirulence on genes *Lr*1, Lr2, and *Lr*2^4 and virulence on gene *Lr*3 are the predominant features of the rust population. Only a few cultures in 1967 were virulent on the backcross line containing gene *Lr*2.

Populations of self-fertilized cultures from races 1, 9, 15, and 161 of wheat leaf rust were studied for inheritance of virulence on the eight standard differential wheat varieties. Race 9 was homozygous at all loci tested, whereas the other races segregated at a number of loci. Recessive genes controlled virulence on the varieties Malakof (gene *Lr*1) and Hussar (gene *Lr*11). Virulence on Mediterranean and Democrat (gene *Lr*3) was governed by a single recessive gene in race 1 and a single dominant gene in race 161. One recessive gene in races 1 and 15 governed virulence to the various alleles of the *Lr*2 locus, whereas in race 161 a second dominant gene altered the expression of avirulence of this gene on Loros (*Lr*2^4). An additional recessive gene for virulence interacted with gene *LrB* in Carina and Brevit. All genes for virulence segregated independently.

Stem Rust of Oats

Epidemiology—The distribution of physiologic races of oat stem rust in Western Canada remained unchanged from 1966. Race C10, a widely virulent race capable of attacking all commercial varieties, continued to predominate; races C3 and C5 comprised the remaining isolates. An interesting shift has apparently occurred in Eastern Canada. In the period 1958 to 1966, C9 and closely related races predominated. In 1967, half the races isolated from Ontario were those related to races found in Western Canada (races C3, C5, C10). The remaining races were typical of those found in the barberry area. This shift may be a result of the barberry-eradication program in Ontario.

Crown Rust of Oats

Epidemiology—Development of crown rust in Western Canada in 1967 was negligible. Among the isolates collected, however, there was a marked increase in virulence on the differential varieties Landhafer, Santa Fe, Trispernia, and Bondvic. The continued usefulness of such sources of resistance in the oat-breeding program is being undermined by this increased virulence.

Genetics—The unit representing genetic recombination in *Puccinia coronata* f. sp. *avenae* was shown to be the aeciospore and not, as had previously been thought, the aecial cup (aecium).

A study of the virulence of uredial isolates of oat crown rust collected during 1952 to 1962 disclosed that the *Pc*-11 gene for crown rust resistance isolated from Victoria is also present in the differential variety Ukraine.

Physiology of Parasitism

Studies on the metabolism of aromatic compounds in rust-infected wheat leaves were carried out with carbon-14-labeled tryptophan as a precursor of indoleacetic acid. Conversion of activity to ether-soluble acids declined in resistant-reacting tissues, and increased in susceptible-reacting tissues. Attempts are being made to identify these metabolic products, and the effect of rust infection on the endogenous levels of free tryptophan is being reinvestigated.

Detached, rust-infected, primary leaves of wheat were used in feeding experiments to study the effect of tryptophan and folate metabolites and antimetabolites on rust development. Sulfanilamide (at $3\times^{-4}$ M), and *p*-arsenosobenzoic acid, 5-hydroxytryptophan, and 5-hydroxytryptamine (each at 3×10^{-3} M) inhibited rust development. As observed by others, *p*-aminobenzoic acid reversed the inhibitory action of sulfanilamide, confirming that rust development requires *p*-aminobenzoic acid, presumably for folate synthesis.

Preliminary analyses indicated that infection of wheat leaves with stem rust resulted in changes of folate levels in the host–parasite complex and that the postinfectional folate drifts in the susceptible reaction differed from those observed in the resistant reaction. These observations were made on bioautographs of paper chromatograms, a procedure with which quantitative data are difficult to obtain. Interpretation of these data is also difficult because most folate compounds are light-sensitive and extremely unstable in air. To investigate the extent of artefact formation, a number of techniques were compared and developed for the extraction, fractionization, and identification of folate compounds.

Extracts from wheat leaves can now be prepared, and stored in liquid nitrogen, without apparent changes in their folate composition, and chromatography of the extracts on diethylaminoethyl-cellulose columns by gradient elution was found to be highly reproducible. In addition, a new analysis of folate compounds by use of thin-layer chromatography was developed. Both procedures are compatible with a differential microbiological assay of the resulting fractions with three folate-sensitive microorganisms. Work is in progress on the identification of the endogenous folate compounds in wheat leaves. Evidently folic acid (pteroylglutamate) is a minor component of the folate fraction. Most of the components are tetrahydrofolates in conjugated forms, probably triglutamates.

Chemical Control of Cereal Rusts

Tests were made with Plantvax[12] (F451), an oxathiin tested previously, and with G 696,[12] a thiazole tested for the first time in 1967. Both of them, when fed to wheat seedlings at rates as low as 1 μg/ml in a nutrient solution, completely inhibited the development of wheat stem rust. A trace of leaf-tip necrosis appeared with G 696 but none with Plantvax.

As a seed treatment, Plantvax failed to control stem rust in wheat seedlings, even at very high rates of application.

Marquis wheat and Kelsey oats were used in field experiments to study chemical rust control. All chemical applications were made as foliar sprays. The wheat plants were inoculated with a mixture of urediospores of wheat stem rust and wheat leaf rust and the oats were inoculated with crown rust. A natural infection of stem rust of oats developed.

In the first experiment with wheat, two spray applications of Plantvax at 3 lb/acre were almost as effective (increase 10.9 bu/acre) as three applications, provided that they were applied at the boot stage and 10 days later. If the first or second application was delayed, the yield increase was not so great. Three applications of Plantvax, at the boot stage, 10 days later, and 24 days after the boot stage, gave a yield increase of 12.2 bu. Nickel–zineb in three applications of 2 lb nickel chloride hexahydrate and 1 lb zineb, on the same dates as the Plantvax applications, gave a yield increase of 7.8 bu. All yields were significantly higher than the control sprayed with the surfactant 0.1% Triton X100, which was used with all treatments.

In the second experiment with wheat, all applications were made three times; at the boot stage, 10 days later, and 24 days after the boot stage. When G 696 was applied at 3 lb/acre, basis pure, it

[12] Manufactured by UniRoyal (1966) Ltd.

resulted in a yield increase of 11.7 bu and at 1 lb/acre, 7.5 bu. Plantvax at 3 lb/acre, basis pure, resulted in a yield increase of 11.5 bu, 3 lb nickel–maneb 11.8 bu, and 3 lb nickel–zineb 11.4 bu. All yields were significantly higher than the control sprayed with surfactant only.

The experiment with Kelsey oats was identical in plan with the first experiment with wheat. All Plantvax treatments gave a statistically significant but low, 4.9 to 6.4 bu, increase in yield. The nickel–zineb treatment resulted in a 5.8-bu increase in yield. It is doubtful that increases in oat yields such as these would cover spraying costs.

In bioassays, myxin, an antibiotic isolated at the Cell Biology Research Institute, Ottawa, did not act as a systemic inhibitor of wheat stem rust in concentrations up to 200 μg/ml.

Maneb used as a spray did not significantly affect the yield of oats in the absence of foliar diseases. In one of three tests, Plantvax applied as a foliar spray significantly decreased yields in one of three varieties.

Parathion, an organophosphorus insecticide, was found to be effective in controlling crown rust development on oats in the field and greenhouse. It did not retard development of wheat leaf rust or wheat or oat stem rust.

CEREAL DISEASES

Smuts

The isolation of haploid monokaryons of *Ustilago nuda* (Jens.) Rostr. by means of media containing benzoic acid derivatives (e.g., anthranilic acid) was developed as a routine technique. One of the mating types grows well on minimal medium that has asparagine as a nitrogen source, whereas the other mating type is a proline-auxotroph; the proline-gene is identical with, or part of, the mating locus. The proline-requiring mating type is unable to grow on complex media such as potato–sucrose–agar because other substances in the media inhibit proline uptake or utilization. A method was developed for inoculation of barley with dikaryotic mycelium, resynthesized from isolated monokaryotic haplonts of *U. nuda.*

Viruses

Oat necrotic mottle virus—A new virus disease of oats was identified in Manitoba. Biologically, the virus appeared to be different from previously described viruses of the Gramineae and it was therefore tentatively named oat necrotic mottle virus. Thirty-two species of Gramineae and 17 species of dicotyledons were inoculated with the virus, but only plants in the genera *Avena, Poa,* and *Lolium* became infected.

Symptoms in leaves of infected oats appeared first as fine chlorotic lines, followed by a general chlorotic mottle. Subsequently, necrosis developed at random on leaf blades and sheaths, accompanied by varying amounts of reddish pigmentation. The chlorotic phase was most pronounced at low temperatures. The virus caused an appreciable reduction in the yield of Russell oats.

Infection occurred readily with the corundum-wipe method of inoculation, and susceptibility increased with the numbers of leaves on the plants. No transmission occurred with five species of aphids or two species of leafhoppers as possible vectors, or through seed or soil.

Infectivity of sap was lost after a few days at 23 C, but was undiminished after 17 weeks at −15 C. Sap was infectious at a dilution of 1:500 but not at 1:1000. The thermal inactivation point was 50 C. Infectivity of sap buffered with phosphate was destroyed after 10 min at pH 4 or less and pH 11 or more.

Oat blue dwarf virus—Oat blue dwarf virus, previously reported as infecting oats, barley, and flax, has been found to infect 13 additional plant species in 5 families. Of the newly recorded hosts, wheat, rape, and carrots are the most notable cultivated plants, whereas stinkweed, *Thlaspi*

arvense L., which may serve as a reservoir of disease, is probably the most important weed host.

Symptoms of the disease, although varying between species, are usually a stunting and a characteristic distortion of plant tissues accompanied by a reduction in seed yield. However, in some susceptible plant species including the cereals, the symptoms may be mild or absent.

The only known vector of the disease is the six-spotted leafhopper, *Macrosteles fascifrons* (Stål).

Field surveys—During surveys in the prairies, fields of two-rowed barley with infections of barley stripe mosaic were found rather frequently. Symptoms of this virus were not apparent in any of numerous fields of six-rowed barley examined. The incidence of barley yellow dwarf was low in Manitoba and southern Alberta, and negligible elsewhere. Most of the isolates of this virus appeared to be mild.

Bacteria

Bacterial infection in wheat—Thirty-two cultures of *Xanthomonas translucens* (Jones, Johns. & Reddy) Dowson emend. Hagborg, selected for relative aggressiveness on the variety Manitou, incited similar reactions on 10 other wheat varieties and did not appear to exhibit physiologic specialization.

Resistance to head discolorations—Head discolorations developed in field plots following an abundant infection of bacterial black chaff established on the leaves by inoculation. Negatively stained smears examined microscopically confirmed the results that the discolorations were almost exclusively those of bacterial black chaff. Three of the new varieties under test, C.T. 282, C.T. 765, and C.T. 769, had moderately heavy infections but lighter than that of Thatcher.

Bacterial blight of barley—Three new varieties under test, B.T. 105, B.T. 604, and B.T. 605, artificially inoculated with bacterial blight had a moderately heavy infection but not heavier than that of the susceptible variety Olli.

Bacterial ring rot of potatoes—Of 28 samples of diseased potatoes submitted for bacterial ring rot determination, 14 were infected with the disease.

Seed Treatment

Cereal plants grown in various locations in the prairies from treated and nontreated seed were assessed for common root rot caused by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur. Root rot in wheat was not reduced by seed treatment. The incidence of root rot in 22 treated and 24 nontreated wheat fields averaged 24.0 and 23.2% respectively. The effect of the soil microflora on *C. sativus* is being investigated.

A detailed review of published and unpublished reports on the effects of seed treatments on yields of cereals and flax grown in the Prairie Provinces of Canada showed: (i) Seed treatment did not increase the yield from healthy and sound seed of cereals and flax. (ii) Heavy infestations by seedling blight fungi rarely occurred and even when present had little effect on yield. (iii) Common root rot of cereals was not controlled by seed treatment. (iv) Some varieties of cereals grown are resistant to smuts thereby making seed treatment unnecessary. (v) Seed treatment usually improves the stand from mechanically injured seed, but the yield is not increased significantly. (vi) Seed treatment increased yields only when heavily infested seed was used.

Ecology of Seed-borne Diseases

A reference collection of seed and soil-borne fungi is being established by making field isolations of various strains and species, and by obtaining cultures from other mycologists. Fungi have been isolated from soil adjacent to treated and nontreated barley seed in field plots to survey the effect of both mercurial and nonmercurial fungicides on the soil microflora.

Over 500 seed samples of wheat, barley, milo, soybeans, rye, and millet either imported by or grown locally in Japan have been examined for surface and internal seed-borne fungi. Few seed-borne pathogenic fungi were found, and the seed-

borne fungus flora for any cereal is similar irrespective of the country of origin.

Pyrenophora teres (Died.) Drechsl. was occasionally severe on barley samples grown in Japan, and *Cochliobolus miyabeanus* Ito & Kurib. was common on rice grown in Japan.

FIELD CROP INSECTS

Soil Insecticides

The probit plane model has been used to derive parameters meaningful in determining the loss of insecticide activity in Manitoba soils. Although there was significant heterogeneity about the regressions for each of the three insecticides used, this did not appear to result from a systematic deviation from the model. Half the bioactivity of diazinon was lost in 10 days; half the bioactivity of Nemacide[13] and Furadan[14] was lost after 22 days. This loss of bioactivity was associated with the percentage of organic matter, cation exchange capacity, and moisture-holding capacity of the soil. It follows that on soils high in organic matter, higher dosages of the insecticides must be applied.

The controlled release of toxicant from plastic-coated pellets that contain insecticide has been demonstrated. Such formulations may provide a means of effectively using insecticides that degrade rapidly and may also help avoid phytotoxic effects.

The bioassay procedure used for the tests is being modified and improved to facilitate further studies. To this end an artificial diet for mass rearing of the onion maggot was developed; *n*-propyl disulfide is included as a feeding stimulant. Insects reared through three successive generations on this medium were similar in size and vigor to insects reared on fresh onions. Thousands of larvae of known age for use in bioassays can be reared on this diet with a minimum of effort. *n*-Propyl disulfide is also an oviposition stimulant. Hence it is now possible to rear the onion maggot continuously without the need of a supply of fresh uncontaminated onions.

[13] Virginia-Carolina Chemical Corp.
[14] Niagara Chemical Division, F.M.C. Corp.

Pesticide Residues

Degradation of malathion, parathion, diazinon, heptachlor, dieldrin, and DDT by the bacteria found in sewage lagoons, under both aerobic and anaerobic conditions, was investigated. The pesticides and their metabolites were separated, and the original pesticides were quantified by gas chromatography.

Within 5 days 96% of the malathion and parathion were degraded aerobically. One metabolite of parathion disappeared by the 5th day and the other was degraded between the 6th and 8th days. Under anaerobic conditions malathion and parathion were both completely degraded within 5 days. The metabolite of parathion, shown not to be paraoxon, was detectable within 8 hr and was not further metabolized.

Under aerobic conditions diazinon was completely degraded within 8 days. Anaerobically, only 35% of the pesticide was metabolized in the same interval. No metabolite of diazinon was detected under either condition.

Under aerobic conditions heptachlor was completely degraded within 14 days; heptachlor epoxide, a metabolite, was detected after the 2nd day and was not further metabolized. The quantities of the epoxide formed were smaller than the amounts of heptachlor that disappeared. Apparently some heptachlor was degraded by a pathway other than epoxidation. Only 67% of the heptachlor was degraded anaerobically within 14 days, and no metabolite was detectable at any time.

Dieldrin was not degraded aerobically or anaerobically, which reemphasizes the extreme persistence of this compound.

The lagoon bacteria did not degrade DDT under aerobic conditions. However, DDT was completely converted to TDE anaerobically, but there was no further conversion.

Biology of Insects

The activity rhythms of five species of stored-product insects are being investigated with an electronic counter that records, at 30-min intervals, the number of insects trapped in wheat. Most experiments were conducted at 25 to 27 C in wheat of 9.5% moisture content. The rusty grain beetle, *Cryptolestes ferrugineus* (Stephens), showed a recurrent period of activity between noon and 6 PM each day; the confused flour beetle, *Tribolium confusum* Jacquelin du Val, was most active between midnight and 6 AM; and the red flour beetle, *T. castaneum* (Herbst), was most active between 6 PM and midnight. The saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus), and the merchant grain beetle, *O. mercator* (Fauvel), were arrhythmic. Locomotor activity, and consequently the amplitude of the rhythms, diminished when the temperature was less than 23 C or the moisture content of the wheat exceeded 10.5%. The results suggest that laboratory experiments, such as bioassays that require insect movement, will be influenced by the time of day during which they are performed.

Insects irradiated by a gamma source at 6.25 to 50 krad take 1 to several weeks to die, depending on the dosage and the susceptibility of the species. In contrast, sterility effects are immediate, and generally occur at dosages well below those needed to kill insects in 2 to 3 weeks. Fecundity and fertility of irradiated adults of the red flour beetle were assessed after males and females were exposed separately to 6.25 krad and then mated; other irradiated males and females were mated with nonirradiated adults. Fecundity was higher in the controls than in mated pairs in which either one or both sexes had been irradiated ($P<0.01$). There was no significant difference in the fecundity of females from pairs in which either sex or both had been irradiated, but significantly fewer eggs hatched than in the controls ($P<0.01$). No eggs hatched when both the male and female of a pair were irradiated. It was found that with doses near the sterility threshold, both sexes had to be irradiated to achieve complete sterility.

Adult longevity and egg production of *T. parabile* Beal were determined at 14 temperatures ranging from 4.4 to 40 C. Adult longevity decreased as temperature increased from 12.8 to 32.5 C. Below 12.8 C longevity decreased rapidly. At temperatures between 22.5 and 37.5 C, the life span of females was shorter than that of males. The lengths of the preoviposition and oviposition periods were inversely related to temperature. No eggs were laid at temperatures below 15.6 or above 37.5 C; a few eggs were laid at 15.6 C, but they were deformed and nonviable. Most eggs were laid at 27.5 and 30 C. The finite rate of increase at 32 C and 70% relative humidity was 1.7 per 8 days. The results suggest that, in those areas of Canada where low winter temperatures and relatively short summers are common, *T. parabile* is unlikely to become a serious pest of stored grain.

In a granary containing wheat, the largest increases in population density of *Cryptolestes ferrugineus* were measured in spots where water had been added. Therefore, in Western Canada, moist areas of grain will be the places of rapid multiplication of insects and, consequently, of heating grain.

Maximum acclimation of adult *C. ferrugineus* to freezing temperatures was achieved by exposing them for 3 weeks to a temperature of 15 C. Half these acclimated adults died after 28 days at −12 C, whereas half the adults acclimated 1 week and 2 weeks died after 2 and 10 days respectively at −12 C.

Studies on other stored-grain insects—*Cynaeus angustus* Leconte, a tenebrionid beetle recently found infesting chicken feed and grain in Manitoba, requires 9 weeks to complete its life cycle at optimum conditions of 30 C and 70% relative humidity. Oviposition was greatest at 32.5 C and 70% relative humidity, and mortality during development was least at 27.5 C. The calculated increase of a population at optimum conditions is roughly 4.5 times per month.

Biology of Mites

Blattisocius keegani (Fox), a predaceous mite, feeds on the eggs of beetles that inhabit stored grain. Under certain environmental conditions this mite may aid in the control of some species of beetles. The second species of predaceous mite, *Haemolaelaps casalis* (Bel), feeds on other species of mites, particularly *Glycyphagus domesticus* (De Geer) and *G. destructor* (Schrank). In Canada *H. casalis* seldom occurs in large numbers and hence probably has little effect on the control of mite populations.

G. domesticus, the house mite, is found infesting many kinds of food. It is capable of a 32-fold population increase per generation. Although it causes economic losses, *G. domesticus* is also of medical importance because it is a source of allergens.

Ecology

Over 1,400 grain samples collected from the import terminals at Kobe, Japan, were examined for insects and mites. This project was carried out jointly by the governments of Canada and Japan from June 1966 to April 1967. The grain had been imported from six countries on 69 freighters. Samples infested with insects contained 2 to 17 kinds, whereas those infested with mites contained 4 to 12 kinds. The percentages of samples from different countries that contained insects, or mites, or both, were as follows: Argentina, 100; Australia, 80; Canada, 69; China, 100; Thailand, 100; USA, 93. Grain from Canada showed a lower level of infestation than that from any other country.

The relationship between the mean monthly temperatures at 116 locations in Japan and the minimum temperatures below which development ceases were established theoretically for major stored-product insects. To assist the Japanese government in its grain-storage problems, maps that show areas potentially vulnerable to these insects were prepared and published. It was concluded that the Khapra beetle could be a serious pest in large warehouses only in the Seto Inland Sea area of Japan.

In Japan, changes in the populations of stored-grain mites with time were followed during 1966–67 by examining 336 samples of rice, wheat, barley, grain debris, and rice straw. Samples were taken from rice fields, granary floors, straw bags, and drums in two farmhouses and five rural granaries in Shiga prefecture. Thirty-four genera with more than 49 species of mites, several of which are new to science, were identified. *G. destructor, Cheyletus eruditus* (Schrank), and *Tyrophagus putrescentiae* (Schrank) were the commonest mites in bagged grain and on granary floors; they were abundant in summer but generally scarce in winter.

In Winnipeg, a new species of stored-grain mite, belonging to the genus *Aleuroglyphus,* was discovered from weevil-infested stored wheat and barley.

Tolerance of mites and insects to insecticides—G. domesticus, T. putrescentiae, Aeroglyphus robustus (Banks), and *Blattisocius keegani* were examined for tolerance to malathion. *T. putrescentiae* was the most tolerant of those studied and had an LT_{50} value of 69 hr when exposed to a malathion residue of 146 mg/sq ft at 76 F.

A. robustus and *T. putrescentiae* tolerated much more phospine (PH_3) in their environment (at least 600-fold) than *Cryptolestes* beetles did. Of the beetles examined, adults of *C. turcicus* (Grouvelle) were slightly more susceptible to PH_3 than were adults of *C. ferrugineus.*

Fumigant Analyses

An improved method was developed for measurement of PH_3 in amounts as small as 10 µg. The PH_3 is removed from closed systems by exhaustive flushing with dry N_2 and is trapped in chilled ethanolic mercuric chloride solution ($PH_3 + 3HgCl_2 \rightarrow P(HgCl)_3 + 3HCl$). The HCl released is determined by potentiometric titration with NaOH. No interference was observed when AsH_3, SO_2, HCN, or H_2S was present at concentrations 1/7 that of PH_3. After storage for 6 hr at room temperature extra HCl was released, apparently by hydrolysis of the $P(HgCl)_3$ complex. This subsequent release of HCl was inhibited for at least 3 days and 3 weeks by storage at 4 and −14 C respectively.

An improved system, based on enzyme activity, was developed to screen small samples of barley for malting and feeding quality. Previous studies indicated that selection for quality characteristics can be made with confidence in the F_3 generation.

The electronic recording dough mixer, developed at the Engineering Research Service in Ottawa, has now been in use for a year. The instrument requires only a 10-g sample of flour and has proved useful in screening for bread-making quality in common wheat. A method that makes use of this equipment has been developed for screening early-generation durum wheat lines for gluten strength.

Work began in 1967 on screening material from oat-breeding programs to detect lines with higher fat content, a suggested feeding quality.

PEDOLOGY

Reconnaissance Surveys

The description of the soils in an area 1,267,000 acres in extent, with reference to chemical and physical properties, agricultural capability, use, and management was completed for the Lac du Bonnet map area. The preliminary soil capability maps were completed for the Grahamdale map area (1,912,000 acres) and the St. Rose du Lac map area (1,647,000 acres). These maps were extended to conform to the National Topographic System (N.T.S.) base. Final field investigation and soil correlation was completed during the summer of 1967, and additional photointerpretation work was done in the fall of 1967 on the Red Rose Washow Bay, an area of 1,750,000 acres. Soil investigation and correlation were completed in the summer of 1967 on the Waterhen map sheet, an area of approximately 2,374,000 acres. The area was traversed with the aid of a helicopter.

Photointerpretation of Swan Lake map sheet, an area of approximately 2,093,000 acres, was started in the fall of 1967.

Detailed Soil Survey Projects

The report on the Portage map sheet, an area of 283,200 acres, includes a section on soil descriptions, physical and chemical analysis, land capability classification, management and land use, irrigation suitability, hydrology, uses of soils for engineering purposes, urban planning, and recreation.

The report of the Winkler map sheet includes information on soil descriptions, chemical and physical analysis, land capability classification, management and land use, irrigation suitability, hydrology, use of soils for engineering purposes, urban planning, and recreation for an area of 178,560 acres. In 1967, a total of 281,600 acres in the Virden map sheet area were mapped, 92,800 acres of this being mapped in detail. Preliminary information on the former Souris and Carroll soils (in the area between Lauder and Souris) shows that these soils are slightly to moderately saline in some areas. Further salinity investigation is required to assess the capability of these soils for irrigation suitability.

The Cormorant Lake map sheet has been chosen for a pilot project for the Biophysical Land Classification (formerly called Wildlands Classification). The project will lend itself to interpretation of the information for forestry, agriculture, recreation, wildlife, and hydrology, and will provide a broad appraisal of the land resources. The area has been tentatively divided into segments or units based on geologic, geomorphologic, and hydrologic components of the landscape. Preliminary study in the area was started in October 1967. Inspections of vegetation, soil, landform, lake shorelines, hydrology, and lake characteristics were conducted.

A groundwater study was started in October 1965 on the Experimental Farm at Morden with the installation of 13 wells. Results showed that the water table fluctu-

ates; in the spring the level was 2 ft below ground surface in several wells and it gradually receded to the 5- to 7-ft level by the fall. The salinity varied among the 13 wells from 0.3 to 9.9 mmhos in May 1966. The dominant cations were magnesium, sodium, and calcium, and the main anions were sulfates, chlorides, and some bicarbonate.

Soil Genesis

In 1964, a study was started to determine the weathered products of the dolomitic material, which constitutes a high proportion of the glacial till in the Interlake Region, and to determine whether or not these products contribute to the clay found in the solum.

A typical degraded Brown Wooded soil was selected for the study. To date, the following characterization has been made: thin sections of the weathered dolomite; X-ray analyses on the clay, silt, and sand fractions; cation exchange analyses; and pebble counts.

Other soils of this catena, such as the Orthic Gray Wooded, the Gleyed Dark Gray, and the Humic Gleysol, will be included to assess the pedological changes and processes, and the degree of weathering.

The soils of the Waitville Catena have been characterized on a morphological, physical, and chemical basis with specific references to the nature of the iron, aluminum, and manganese forms to determine if chemical criteria can be used to separate the drainage members in a chronosequence. The mineral fractions have been separated and retained for further studies on the effect of drainage on mineralogy.

A preliminary study was started in 1966 on the morphological, physical, and chemical characterization of peat soils located in the southern fringe of the Boreal Forest Region in the Manitoba Lowlands. The publication *Organic Soils of Manitoba* contains site description, profile descriptions, and analyses of organic soils.

Soil Capability Classification for Agriculture

The systematic soil capability classification of soils in Manitoba for the Canada Land Inventory has been completed for most of the settled southern agricultural area of the province. The information is available for the Virden, Brandon, Winnipeg, and Riding Mountain N.T.S. sheets in the form of maps compiled at the scale of 1:250,000 (about 1 inch = 4 miles). Included with the maps are brief descriptive legends that explain the capability classification and a general description of the area, climate, main soil characteristics, and agricultural settlement.

Compilation of more detailed capability maps at the scale of 1:50,000 (about 1.25 inches = 1 mile) for computer input information is being prepared for areas in the province where soil survey information is available.

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INTRODUCTION

This report outlines the significant results of our research for 1967. Our last published report was for 1965 and 1966. From now on, we expect to publish results annually.

None of the research is described in detail. In the case of long-term projects, significant progress is mentioned. Results of our testing programs provide proven practical recommendations for the guidance of farmers in Saskatchewan.

J. Roe Foster
Director

[1] On educational leave at Rothamsted, England.

METEOROLOGY

In 1967, only 2.08 inches of precipitation was recorded in the growing season, April 1 to July 31. The heaviest rain amounted to 0.37 inch. An additional 0.46 inch on Aug. 7 was of some value to late crops. The amount in 1967 marks the lowest precipitation ever recorded in the growing season in the past 71 years. Fortunately, mean temperatures were close to normal. The average mean temperatures for the summer months were 5 F higher in 1961 and 6 F higher in 1937, two previous drought years. Extended periods of extreme heat did not occur. Evaporation for the period May 1 to Sept. 30 was 25.4 inches. This was 4.9 inches higher than the 32-year average, but 3 inches below the amount in 1961. A total of 1,085 hr of bright sunshine was recorded during the growing season. This amount was much higher than the 75-year average.

POULTRY

Selection Studies with White Leghorns

In a cooperative project with the Research Station at Brandon, Man., white leghorns are being selected under two rearing environments, namely, full-fed and feed-restricted. Early results indicate that the strain selected under restricted feeding performs equally well in a full-fed and feed-restricted environment, but the strain selected under full-feeding does not perform as well in a feed-restricted environment. More data will be required to fully evaluate the results.

A comparison of feed costs and returns from eggs was made for both environments. Birds reared under restricted feeding again gave higher returns over feed costs than full-fed birds, even though laying-house mortality was 2% higher in the restricted birds than in the full-fed birds.

FIELD HUSBANDRY

Rotations and Soil Fertility

Rotations—Plots sown continuously to wheat for the past 10 years averaged 20.5 bu/acre in 1967. At seeding time, 40 lb N and 10.5 lb P/acre were applied, and wild oats were effectively controlled with a fall application of triallate. When only two crops were grown after summerfallow, 1 bu less wheat was produced per cultivated acre than when continuous wheat was grown. The second crop after summerfallow in rotations containing a grass–legume mixture gave as high a yield as the stubble wheat that was fertilized in grain rotations.

In one rotation that included a grass–legume mixture, wheat grown on summerfallow for the past 56 years averaged 35.9 bu/acre. This field yielded 30.3 bu in 1967. Soil fertility is still high in these fields. During the past 10 years, when commercial fertilizers were applied to half of each plot, yields were not increased.

Fertilizer Use

Different rates of fertilizers have been applied with wheat on five farms located on Indian Head heavy clay. The soil rated low or very low in available P and high or very high in available N. Soil moisture in the summerfallow on fields of the Experimental Farm averaged 6.25 inches of available water, and the total precipitation for the five farms averaged 2.19 inches from May 1 to Aug. 31 in 1967. The check plots yielded 29.4 bu/acre this year. Yields were increased by 7 bu/acre when 8.7 lb P/acre were applied. This increase is 4 bu/acre greater than the average increase in the previous 9 years, which shows

more efficient use of water by the fertilized crop under the extreme moisture stress this year. Higher rates of P resulted in small additional increases. The crop did not respond to additional N.

Fertilizers were applied to fields having a rolling topography. The soil was classed as a Ryerson loam. Forty and 80 lb 11-48-9, 85 lb 23-23-0, and 90 lb 33.5-0-0 were applied to five different slope positions. The yield of wheat averaged 12 to 75% higher on the slope positions than on the crown. With the exception of the area in the depression, the response to fertilizer was fairly consistent for all locations on the slope. This indicates that special attention does not need to be given to the eroded knolls when fertilizer is applied with wheat on summerfallow. The increase in yield of wheat with 80 lb 11-48-0 and 85 lb 23-23-0 was 4–5 bu in 1967. This is very close to the 3-year average increase.

The comparative response of different grains to fertilizer—Fifty lb 11-48-0 was applied to Manitou wheat, Stewart 63 durum, Garry oats, and Conquest barley. The increase in yield was much the same for all grains, but increases were most consistent with Manitou wheat; Conquest barley rated next, and oats and durum wheat increases were slightly less.

Fall rye sown on summerfallow responded much the same as wheat to phosphate fertilizer. The average increase with 4.3 lb P/acre was 4.3 bu/acre, and with 8.7 lb P, 5.3 bu/acre. Additional N did not increase yields as these plots tested 70 lb/acre of available N in the spring of 1967. Fall rye sown on stubble responded much the same to phosphorus as rye sown on summerfallow, but yields were increased by the addition of 20 lb N/acre. Higher rates of N did not result in economic increases, even when the soil test was low.

Effect of manure on soil fertility—For the past 21 years, 12 tons of manure have been applied to some plots once every third year. In 1967, yields of wheat on nonmanured plots were 23.9 bu/acre, and on manured plots 31.8 bu. The increase for the whole period has averaged 3.4 bu/acre. In 1967, the soil in the checks contained 49 lb available N and in the manured plots 76 lb; in the checks 16 lb available P and in the manured plots 27.2 lb. Increases in yield were much greater in 1966 and 1967 than in previous years.

Stubble crops—Rates of N from 5 to 80 and P from 8.7 to 17.4 lb/acre were applied to wheat after wheat on five farms located on Ryerson loam, and two farms on Oxbow loam. The increase in the yield of wheat ranged from 1.2 to 11.9 bu/acre. The maximum response resulted when the rates of fertilizer used were based on the recommendation from the soil test. Even under the drought conditions in 1967, the response did not differ much from the 3-year average.

Forage crops—During the past 5 years, yields of a brome–alfalfa mixture were increased by 0.25 ton/acre when 30 lb N was applied to the crop. Higher rates of N did not result in economic increases. Spring applications were slightly more effective than fall. Increases did not result from surface applications of P. When 60 lb N and 26.2 lb P/acre were applied once in 3 years, yields were not increased in the second and third year after application. In other locations in eastern Saskatchewan, the use of N at rates above 20 lb, alone or in combination with 8.7 lb P, proved to be a questionable practice with brome–alfalfa mixtures.

Even under the very dry conditions in 1967, N increased bromegrass yields. Annual applications of 40 lb N/acre over the past 10-year period resulted in an average increase of 0.70 ton/acre. Even though the soil tested very low in available P, bromegrass yields were not increased when P was spread on the soil surface.

Weed Control

Green foxtail—Six new chemicals were applied as preemergence sprays and seven as postemergence sprays at a number of different rates, to green foxtail growing in wheat, oats, and barley. In 1967, most of these chemicals did not kill or sufficiently retard green foxtail to warrant their use in Western Canada. In some cases, when control was fairly satisfactory, crops were injured. Three of these herbicides, Topcide,[2] MSMA, and GS 14260,[3] will be tested again in 1968.

[2] Spencer Chemical Division, Gulf Oil Corp.
[3] Fisons (Canada) Ltd.

Canada thistle—Ten chemicals were applied at a number of different rates to Canada thistle growing in fields being summerfallowed. Picloram applied at 2 oz/acre in June and at 2 oz/acre again in August, and amitrole applied at 9 lb/acre in June, resulted in the complete kill of all top growth. Little regrowth occurred later in the season. Although picloram appears very promising, more information is needed on the tolerance of the cereal crops to residues left from these rates.

Continuous use of herbicides—Since 1948, an ester of 2,4-D, an amine of 2,4-D, and an ester of MCPA have been applied at a light and heavy rate. Because of dry surface soil, few weeds emerged on any of these plots in 1967, but differences were apparent. On the plots where the heavy rate of chemical was used, weeds averaged 1 per sq yard; the light rate, 1.5 per sq yard; and the checks 7.4 per sq yard. There were fewer stinkweeds and lambsquarters on the treated plots than on the checks. Considerably more Russian thistles were noted on the plots treated with MCPA.

Wild oat control—The effect of different quantities of stubble cover on the eradication of wild oats has been studied for the past 11 years. All stubble was burned off some plots, all straw from the combine was left on others, and 1 ton of straw was added to a third group. Half the plots in each treatment were cultivated in the fall. In 1967, the crops with the heavy combine stubble averaged 14 wild oats per sq yard, those with the normal quantity of straw, 5 per sq yard, and the plots that were burned, 0.5 per sq yard. In all cases, fall cultivation reduced wild oats by 50%. This indicates that more attention must be given to wild oat control when heavy combine residues are maintained to prevent erosion.

CEREALS

The very dry season resulted in variable stands and yields, particularly in the cooperative tests of varieties and plant breeders' material. Several tests were discarded because of uneven emergence. There was no rust to indicate differences in rust resistance, but the dry conditions provided a good basis to isolate drought-tolerant varieties. Manitou spring wheat has proven to be just as drought-tolerant as Canthatch or Thatcher. Sioux oats averaged the highest in yield, followed by Kelsey and Fraser. Galt was the highest-yielding barley, with Jubilee a close second. The dry conditions appear to have affected Conquest more than other varieties. BT-304 (a potential new malting barley) yielded slightly more than Conquest. Noralta and Redwood 65 were the two best flax varieties.

FORAGE CROPS

The extremely dry growing season had the effect of producing very low yields and narrowing the usual differences between species and treatments. All 1967 test seedings of perennial crops failed to establish.

Management Practices

Ammonium phosphate fertilizer (11-48-0) at 20, 30, 40, and 50 lb/acre, applied with the seed of five grasses and alfalfa in 1966, had no effect on herbage yield in 1967. The seedling growth in 1966 appeared to be more vigorous when fertilized, but there was no effect on percentage stand. The extremely dry conditions would prevent optimum growth. There was no difference in yield of grass–alfalfa mixtures when sown in 6-inch or 12-inch-spaced rows. Alfalfa and bromegrass in alternate rows yielded the same as when the alfalfa and grass were mixed in the same row.

A large-plot pasture test of species of forage crops was converted to a 3-year rotation of fallow–wheat–wheat, and fertilizer applied at various rates. Standard field-size machinery was used. The yield of wheat was higher after crested wheatgrass than after any other treatment. The average yields of fallow wheat in bushels per acre were: following Fairway crested wheatgrass, 26.5; Summit crested wheatgrass, 26.4; Russian wild ryegrass, 21.5; intermediate wheatgrass, 22.9; bromegrass, 22.3; brome and alfalfa (Ladak), 24.7; brome and alfalfa (Rambler), 23.6; oats, 21.9. These plots had a full-fallow year; the frequently observed depressed yields after perennial forage crops did not occur.

Plant Breeding

All plants in the isolated blocks of large-seeded wheat crossed with wheatgrass breeding material produced a satisfactory quantity of good-quality seed. There does not appear to be any sterility or incompatibility in the plants used. All the plants in the crested wheatgrass isolated crossing block produced satisfactory yields of good-quality seed, which shows a satisfactory relationship among the plants included. Selection to improve the seed size of Echo oilseed rape, *Brassica campestris* L., is encouraging. Preliminary test data indicate a satisfactory increase in average seed size accompanied by an increase in yield, and in some cases higher oil content. Two or three lines are worthy of being included in the cooperative tests project group. A recent survey showed that the Echo variety occupied 43% (290,000 acres) of the rape acreage in Saskatchewan in 1967. There is reason to believe that the percentage of Echo grown in Alberta and Manitoba was similar.

SOILS—HORTICULTURAL CROPS

Vegetable Variety Trials

Vegetable variety evaluation trials have been conducted with the view of recommending outstanding varieties for gardens in southeastern Saskatchewan. In addition, we have cooperated with other plant breeders in Western Canada to breed and select better varieties of tomatoes and potatoes. To date, the cooperatively conducted tomato-breeding project with the Research Station at Morden has produced an early maturing, large-fruited tomato, which has shown excellent parental qualities for further breeding and selecting work.

Fertilizer for Potatoes Grown under Irrigation

Although potato yields were much lower in 1967 than in previous years, the increases in yield (or the responses) after the application of N and P fertilizers were similar. The combined application of N at 50 lb/acre and P at 22 lb/acre produced significant responses in total and marketable tuber yields of 48.2 and 36.9 cwt/acre, respectively. However, larger total and marketable tuber yield responses of 68.2 and 48.5 cwt/acre and of 66.7 and 54.5 cwt/acre, respectively, were obtained by applying 100 lb of N with 66 lb of P, and 150 lb of N with 66 lb of P. Yields after separate applications of N and P fertilizers were variable and generally much lower (particularly yields of marketable tubers) than those obtained from combined applications.

Rotations for Potatoes Grown under Irrigation

Experiments conducted for the past 6 years indicate that monoculture of potatoes had significantly ($P = 0.01$) lower yields per plot than either a 3-year or a 6-year crop rotation system. Yields in the 3-year rotation of potatoes, sweet clover, hay and break were greater, and contained a considerably higher percentage of marketable tubers, than yields in the 6-year rotation of potatoes, potatoes, alfalfa and crested wheatgrass, hay, hay, hay, and break. The application of manure in these rotations had very little effect on potato yields.

PUBLICATIONS

Research

Molberg, E. S., E. V. McCurdy, A. Wenhardt, D. A. Dew, and R. D. Dryden. 1967. Minimum tillage requirements for summerfallow in Western Canada. Can. J. Soil. Sci. 47:211–216.

Research Station
Melfort, Saskatchewan

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INTRODUCTION

Since 1955, the Research Station, Melfort, has specialized in research on the production and utilization of forage. This is a cooperative undertaking involving scientists in animal nutrition, forage crops, and soil fertility. In the summer of 1967, two new pasture projects were started; one dealt with a comparison of four animal management practices, while the other was concerned with a comparison of crested wheatgrass and Russian wild ryegrass pastures.

The 1967 growing season was one of the driest on record. The rainfall was only 2.91 inches from April 1 to August 31, about 31% of the longtime average (9.32 inches) for Melfort. Despite drought, pasture production on the new project was remarkably good, because the land was summerfallowed before seeding in July of 1966 and there was adequate moisture in 1966. Yields of cereal crops were below normal but better than expected.

The main additions to facilities during 1967 were a feed processing and storage building to facilitate studies in the use of roughages in rations for growing and fattening cattle and auto analyzer equipment to facilitate chemical analyses of soils, plant materials, and animal feeds.

S. E. Beacom
Director

[1] Appointed June 28, 1967.

PASTURE RESEARCH

Animal Management Practices

An experiment was begun in the summer of 1967 to compare four systems of managing steers on pastures to provide maximum animal gain and efficient pasture utilization. The systems were: "put and take" stocking; feeding back surplus pasture conserved as silage while maintaining an average stocking rate; feeding oat soilage; or rolled barley to maintain animal gains at the level occurring during the period of peak pasture production. The pasture was a bromegrass – Rambler alfalfa mixture seeded in 1966. The results of the four treatments were: daily gains, 2.62, 2.65, 2.58, and 3.06 lb per head; gains per acre, 299, 287, 375, and 478 lb. Because of an unusually dry season, initial stocking rates of 2, 1.25, 2, and 2 steers per acre had to be reduced to 0.5, 1.0, 1.0, and 1.1 steers per acre for the four treatments respectively. Average final liveweights of steers remaining to the end of the season were 957, 959, 967, and 1,040. Grain-fed steers were well finished; 12 graded Canada Choice, 13 Canada Good, and 1 Canada Standard. The returns per acre were the highest on this treatment. Yields of pasture dry matter averaged 3,382; 3,762; 3,622; and 3,514 lb/acre for the four treatments.

Forage Comparisons

Russian wild ryegrass vs. crested wheatgrass for pasture—In a recent pasture project in which steers grazed Russian wild ryegrass, crested wheatgrass, and bromegrass pastures in rotation, the apparent gains made on the crested wheatgrass pastures exceeded those made on the Russian wild ryegrass pasture by about 50%.

In the summer of 1967, grazing steers were confined to one or the other of these two pasture species throughout the grazing season. Gains averaged 222 lb/acre on the Russian wild ryegrass pasture and 173 lb/acre on the crested wheatgrass pastures. Because rainfall was about one-third of normal and the moisture stress on the two pasture stands was unequal during the previous year (considerably higher hay yields were taken from the crested wheatgrass fields) the results may not be typical. Nevertheless, the superiority of the Russian wild ryegrass under these conditions was demonstrated.

Palatability of crested wheatgrass varieties—Palatability studies conducted from 1963 to 1965 showed that sheep preferred Fairway crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., to S-5565, a tall-growing strain of the same species. To determine if this difference in acceptability or palatability would affect animal production, a replicated grazing trial was established in 1965. After 2 years of testing, no significant difference in liveweight gain per acre has occurred between strains when grazed separately or when free choice was allowed.

Northern Rangeland Investigations

Studies are under way in the northern parkland of Saskatchewan to determine the long-term productivity of these areas when used for pasture. Investigations include ways of controlling woody regrowth, effect of fertilizers, herbicides, and other treatments on yield and species composition.

ANIMAL SCIENCE

Beef Cattle

Grinding forage for wintering calves—Tests are under way to determine the optimum size of screen to use when grinding roughages for steers. Three forages were ground to pass through four different screens (3/16, 1/2, 1, and 2 inch diameter openings) and the resulting product was fed to steer calves as the sole ration for 90 days from January to April.

Steers fed the ground, good quality bromegrass gained an average of 1.98

lb/day and consumed 21.5 lb of feed with performance not well related to size of screen used. The steers that were fed crested wheatgrass gained 1.64 lb and consumed an average of 17.4 lb of feed each. The steers showed a slight but not important tendency to gain more and eat more as the screen size was reduced. When the steers were fed poor quality slough grass, gains were maximized (0.91 lb/head per day) and the feed:gain ratio was highest (18.7:1) when the 1/2 inch screen was used.

Quality and level of ground roughage in steer finishing rations—Twelve lots, each comprising four Charolais × Hereford and four Aberdeen Angus steers were self-fed finishing rations containing good, medium, and poor quality ground (5/16 inch screen) roughage at levels of 20, 45, 70, and 95% of the ration. Initial and final weights of the Charolais crossbreds were 850 and 1,173 lb; of the Angus 723 and 965 lb.

Combining roughages and breeds, steer gains averaged 4.00, 3.16, 2.89, and 2.54 lb when roughage comprised 20, 45, 70, and 95% of the ration respectively. Averaging roughage levels and breeds, average daily gains were 3.09, 3.15, and 3.22 lb/head daily on the rations containing the good, medium, and poor quality roughages respectively. Poor quality roughage had no adverse effect on gains except when included at the highest level. Both breeds responded similarly to changes in the level of the roughage component of the ration, whereas the Angus appeared to do proportionately better on the poorer quality roughages than did the Charolais–Hereford crossbreds.

All steers graded in the top three grades. However, since dressing percentages and grades tended to be reduced as the roughage level increased, returns were generally lower as the roughage level was increased. The most notable exception was the lot fed 95% good quality roughage. In this lot daily gains averaged 3.04 lb/head, dressing percentage was 54% (as high as the lot fed 20% grain), and steers graded 4 Canada Choice and 4 Canada Good. Returns per steer were 85% of those obtained on the high grain lot and they greatly exceeded the returns obtained from steers fed the 45 and 70% level of good quality forage. Several cases of bloat occurred on these latter two rations and on the ration containing 70% medium quality roughage.

The test shows that beef of acceptable quality can be produced on rations that contain higher than normal amounts of roughage. At current feed prices, however, it might be economically unsound.

Swine

Fiber level in breeding rations—Yorkshire gilts, fed ad libitum, either of two breeding rations, which were equivalent in crude protein (C.P.) level (18.9% C.P.) and gross energy content (3.62 kcal/g), but different in fiber level (H.F. 12.7% vs. L.F. 8.5%),[2] showed similar productivity in their first litters. The average litter weight, number of pigs born, number born alive, and number weaned were 30.0 lb, 10.9, 9.9, 9.1, and 28.9 lb., 11.4, 10.3, 9.9 for the H.F. and L.F. groups.

Supplementary copper in growing rations for gilts—Ten Yorkshire gilts were fed ad libitum rearing and finishing rations (19.4 and 15.3% C.P.), which contained 10.0 and 5.0% of an equal mixture of fishmeal and soybean meal. Another group of 10 gilts was given the same rations, with the addition of 1 lb of copper sulfate per ton (equivalent to 125 ppm of copper). Over the period that the gilts were 50–200 lb liveweight the copper-supplemented group exhibited a 9% improvement in growth rate and efficiency of feed conversion.

[2] H.F. = high fiber
L.F. = low fiber

Crop Fertilization

Fertilizing spring wheat and rapeseed on summerfallowed land—Experiments are in progress on six soil types in the Thick Black, Degraded Black, and Gray Wooded soil zones to further evaluate factors controlling P requirements of wheat and rapeseed. The results show that plant analyses supply accurate information on the nutritional status of a crop. At lower levels of fertilization, P contents of plant tissue decreased. The percentage of P in the plants showed substantial increases at higher levels of fertilization, when maximum yield responses were approached. Fertilizing with P beyond the level required for maximum yield response resulted in further accumulation of P in the plant material. Yield responses of wheat and rapeseed were higher in seasons of low precipitation than in seasons with ample moisture. This difference was more pronounced on soils with poor moisture characteristics, such as the light-textured soils.

Fertilizing malting barley on summerfallowed land—The addition of K fertilizer to malting barley on soils very high in available K reduced the protein content by an average of 0.5%. When P fertilization satisfied yield requirements, protein levels of the grain increased up to 1.3%. However, P decreased protein contents when fertilization was less than that required for maximum yields. Because the summerfallowed land was very high in available N, the addition of N fertilizer consistently reduced yields and increased protein contents. In 1965, K fertilizers reduced lodging and thereby increased yields. In 1967, K fertilizers increased P uptake by the plants, which resulted in increased yields. When K was applied in presence of added N fertilizer, the depressing effect of added N was eliminated. Plant P contents were not increased by K fertilizer where P fertilizer had been applied. In 1966, no significant effect on yield from K fertilizer was present.

Residual effects of phosphorus—Ammonium phosphate fertilizer was broadcast on crested wheatgrass – alfalfa and bromegrass – alfalfa forage stands over a period of 3 years. This resulted in an accumulation of up to 29 ppm of $NaHCO_3$-soluble P in the top 6 inches of the soil with most of it accumulated in the top 2–3 inches. The levels of available P in the fertilized and unfertilized areas were so high that two grain crops grown on the area did not respond to the original or added P fertilizers. However, 2 years of cropping substantially reduced and practically equalized available P levels. Fertilizer additions of up to 36 lb of P/acre to both crops failed to maintain soil test levels in the original plots. These results show that a large amount of fertilizer P is changed to unavailable forms or that a substantial amount of excess P is removed through luxury consumption by the crop. These possibilities are being investigated further.

Phosphorus fertilizer for forage crops—Broadcast P fertilizer is immobilized in the top 3 inches of Melfort soil. In an attempt to overcome this phenomenon, equivalent amounts of monoammonium, diammonium and monocalcium phosphate were incorporated into the top 6 inches of the soil in the fall of 1964. In the spring of 1965, 80 to 90% of the added P was recovered in the $NaHCO_3$-extractable form from the 0 to 6-inch soil layer. In the spring of 1967, the percentage of available P recovered varied from 45 to 59. Rates and sources of P did not affect the percentage recovered at both sampling dates. Differences in the amount of P recovered in the harvested forage did not account for the increased losses of available P at higher levels of fertilization.

Solution and granular nitrogen fertilizers for crested wheatgrass – alfalfa—An 8-year-old stand of crested wheatgrass – alfalfa was fertilized with four rates of N (0, 50, 100, and 150 lb/acre) from each of four fertilizers (granular NH_4NO_3, urea plus NH_4NO_3, urea, and a solution of urea plus NH_4NO_3). Dry matter yields were not significantly affected by either rate or source of N, although the 150-lb rate of the solution of urea plus NH_4NO_3 gave the highest yield and the 50- and 100-lb levels of granular urea plus NH_4NO_3 and

the 50-lb level of urea depressed yields slightly. Owing to the dry conditions, dry matter yields were low (435 to 853 lb/acre).

Relationship of fertilizer responses to soil testing—A factorial experiment including five levels of N and two levels of P applied to Conquest barley as the second crop after fallow is under way. The experiment, which includes three soil zones (Gray, Black-Gray, and Black) is located at six sites.

In 1967 yield response to N did not conform to what was expected on the basis of soil tests. The effect of such factors as soil moisture, soil temperature, the nitrifying capacity of the soils and their interaction is being investigated.

Soil Management

Organic amendments for Podzolic soils under controlled greenhouse conditions—Two Gray Wooded soils (Garrick loam and Waitville loam) and a Black-Gray soil (Nipawin loam) were used in a greenhouse experiment to determine the effect of various organic amendments on the physical properties of the soils and on crop yields. Peat, manure, straw, and sawdust were applied to one or more of the soils at 2.5% of soil weight (about 25 tons/acre). A complete fertilizer was applied to all treatments to eliminate nutrient effects. Five crops were grown in succession.

The addition of peat significantly increased the yield of the first crop of Pembina wheat on Garrick and Nipawin loam. The effect of this amendment on yields of the succeeding crops was variable. Microbial activity in decomposing the amendments appeared to restrict growth of the second crop (Conquest barley) on Garrick loam by limiting the uptake of N. Barley yields showed a positive correlation to protein content of the grain with the exception of the peat treatment on Garrick loam and the check and peat treatments on Waitville loam.

Modulus of rupture measurements of the soils after the fifth crop showed that an organic amendment lowered the crust strength of all soils.

Amendments and the high N treatment increased the moisture-holding capacity of the soils by as much as 7% of the soil weight. When the moisture tension of the soil was maintained at a constant level, it did not affect yield results.

Methods of treating combine straw and stubble—When wheat was seeded on the same plots for 13 consecutive years or when wheat was grown following summerfallow in each of 7 years, there was little advantage to fall tillage and no advantage to burning. In the first case, however, light fall tillage year after year has maintained the infestation of wild oats and Canada thistle at a significantly lower level than that occurring on untilled or spring-burned plots. When stubble was left standing over winter, about 0.25–0.50 inch more water was stored in the top 4 ft of soil. However, this had little effect on yield.

Summerfallow methods—The effects of various methods of summerfallowing on crop yield, weed control, and the moisture retention, nutrient content, and erodibility of the soil is being studied. The moisture, available nutrient buildup in the soil, and crop yields have been as good or better when the summerfallowing was done entirely by chemical means as when done by tillage. The most effective weed control was obtained when both tillage and chemicals were used. Provided broad-leaved weeds were adequately controlled with herbicides, delaying tillage until July 1 led to the retention of more crop residue, better soil protection, and better yields than when tillage was done earlier. The use of disc, shovel, or rod-type weeders resulted in higher yields than did the use of the plow.

About 20% (4 inches) of the precipitation during the 21-month summerfallow period was stored in the soil; half of this occurred during the first fall and winter. Over the past 10 years yields on well-managed, weed-free stubble land averaged at least 75% of those obtained on summerfallow land.

Methods of seeding fallow and stubble land—Seeding wheat on uniform summerfallow with a hoe press drill without preseeding tillage, but followed by rod weeding for weed control produced the highest yield of wheat over a 4-year period. When seeding wheat and oats on stubble land, the use of the discer (wide-level disc

harrow) with seed box and heavy packer attachment (a once-over tillage and seeding unit), resulted in yields as high as or higher than those obtained when other methods were used.

The use of the discer and harrows before seeding with the double disc press drill provided a good seedbed over a wide variety of conditions and produced high yields of cereal grains on both summerfallow and stubble land.

Soil Chemistry

Automated soil analyses—Automated methods were developed for P analyses of 0.5 M $NaHCO_3$ soil extracts and for nitrate and ammonium N determinations in 2 N KCl extracts using a Technicon Auto Analyzer. P was determined at a rate of 30 samples/hr using the ascorbic acid reduced phosphomolybdic blue color method. Ammonium was determined by the hypochloride reduced alkaline-phenol method at a rate of 50 samples/hr. Results compared closely with the Bremner steam distillation method. After reduction by hydrazine sulfate, nitrate N was determined as nitrites using sulfanilamide and *N*-1-naphthylethylenediamine dihydrochloride. Nitrate analyses averaged 2 ppm higher than the Bremner method, but were closely related. Forty samples per hr were analyzed.

PLANT SCIENCE

Cereals

Oat breeding—The main objective of the oat breeding program is to combine good yield with resistance to lodging, stem rust, and smut. Extensive use has been made of Exeter and Eagle as parental material, since both are high yielders in this region when rust is absent. Use has been made of Rodney, Glen, and Pendek as lodging-resistant parents, and material for resistance to rust and smut was supplied by the Research Station, Winnipeg. Some 420 lines representing the selected progeny from several crosses were forwarded to the Research Station, Winnipeg, where they were tested for resistance to stem rust races 6 F and 7 A. From the group, 55 lines that showed resistance to stem rust equal to Garry and Harmon were selected for further investigation.

Triticale—Manitou wheat and several strains of Triticale were compared in a replicated test. All of the strains yielded significantly less than Manitou, and matured from 6 to 15 days later. However, the protein content (% N $\times$ 5.7) of the Triticale strains ranged from 17.6 to 19.3%, whereas that of Manitou averaged 15.9%.

Crop sequence study—A study comparing the performance of different cereal crops grown on grass legume sod – fallow has been conducted for 8 years. The results show that flax and oats were the most profitable crops to follow sod breaking. The 8-year average yields (lb/acre) of the crops tested were: oats 2,206; barley 2,066; wheat 1,448; flax 836; Argentine rapeseed 833; and Polish rapeseed 812. A N–P fertilizer (averaged 5 to 20 lb N and 20 lb P/acre depending on soil tests) resulted in good yield increases with all crops except flax.

Wheat, barley, flax, and rapeseed were compared when grown on wheat, oats, barley, flaxseed, and rapeseed stubbles over a 3-year period. The average yields (lb/acre) when each crop was fertilized with ammonium phosphate fertilizer were: barley 1,867; wheat 1,270; flaxseed 613; and rapeseed 403. This fertilizer produced an economical increase in yield on all crops tested.

Rotation studies—Rotation studies in northeastern Saskatchewan showed that the gross return per acre was increased when the acreage in black summerfallow was reduced from a level of 50 to 33% or less. On Melfort soil, when half the crop land was summerfallowed each year, the average production of wheat over a 9-year period was 990 lb/acre, compared with 1,170 lb when one-third of the land was in summerfallow and 1,254 lb/acre when all the land was cropped each year. These studies also showed that on degraded soil the gross return per acre was

increased when grasses and legumes were included in the cropping system on a regular basis.

Swathing rape—Echo, *Brassica campestris* L., and Target, *B. napus* L., rape were swathed at 2- or 3-day intervals after reaching a moisture content of 60% until they were ready for straight combining. The moisture content of Echo and Target dropped to 20% at 90 and 105 days after seeding. Although yields were highest when the rape was swathed at a moisture content of 20%, no significant reduction in yield occurred when swathed at a moisture content of 30% or less.

Forage Crops

Evaluation of birdsfoot trefoil and sainfoin—The introduction of numerous species, varieties, and strains of birdsfoot trefoil (*Lotus* spp.) and sainfoin (*Onobrychis* spp.) resulted in the selection and development of many lines that have superior winterhardiness and yield. These nonbloat-producing legumes are of interest not only for hay or pasture, but also because they are potentially important to this area as seed and nectar crops.

Sainfoin demonstrated its excellent drought resistance in 1967 when a seed yield of more than 2,000 lb/acre was obtained from a winter-hardy selection established in 1966.

The use of bumblebees for pollinating red clover—The number of bumblebees (*Bombus* sp.) working tetraploid red clover was increased from 42 to 300 per 100 m^2 as a result of introducing transportable hives to the area. These populations were maintained or increased by providing sufficient nest boxes to accommodate the nest-searching queens for the following spring. Several daughter queens (*B. perplexus*), marked with paint, returned to their parental nests after hibernation.

Of the nine *Bombus* species established in artificial nests, the most numerous were *B. perplexus, B. rufocinctus,* and *B. borealis.* In 1967, a total of 204 out of 523 nests were accepted. Nest boxes with multiple entrances were readily accepted and defended by *B. rufocinctus,* but were completely rejected by *B. perplexus,* a relatively docile species.

The use of alfalfa leaf-cutter bees for pollinating alfalfa—Cocoons produced by *Megachile rotundata* F. during 1966 were overwintered at 40 F and allotted at rates of 10,000, 7,000, and 4,000/acre to three separate alfalfa seed fields. Seed yields were 372, 210, and 156 lb/acre. In the same general area, seed fields not pollinated by *M. rotundata* averaged 58 lb of seed/acre.

The extremely dry growing season encouraged insect activity, but was detrimental to the production and duration of the alfalfa bloom. Pollination of the test fields was complete by the first week of August. The bees were then moved to second-cut alfalfa where sufficient bloom permitted cocoon production to continue until late August. During the summer an increase in cocoons from 186,000 to over 700,000 was obtained.

Susceptibility of grass species to diallate and triallate—Nine grass species were sown in soil that had been sprayed just before seeding with 0, 1.25, and 2.5 lb/acre of diallate and triallate. Grasses ranged in sensitivity from Kentucky bluegrass, *Poa pratensis* L., and bromegrass, *Bromus inermis* L., which were extremely susceptible to either rate of both chemicals through to Russian wild ryegrass, *Elymus junceus* L., a highly resistant species. Diallate was more damaging than triallate and the high rate was substantially more harmful than the 1.25 lb/acre rate of either chemical.

Seedings were also made in the spring in soil that had been treated the previous fall with 1.25 lb/acre of diallate or triallate. Damage was not as severe as it had been in soil that had been treated just before seeding, but this difference may be due to the dry conditions at seeding time and throughout the growing season. The harmful effects of the chemicals seemed to be diminished as the season progressed, because delayed seedings showed generally less damage to susceptible grasses.

Horticulture

Vegetable variety tests—Several kinds of vegetables were tested. New, promising varieties of green beans, beets, broccoli, cabbages, cauliflowers, corn, and squash

were tested for the first time in 1967. Of 18 varieties of corn tested, Spancross gave highest yields ($P < 0.01$) and matured in 90 days after seeding. Supercrop, a cucumber with good pickling and slicing qualities, yielded the highest of 10 varieties tested. Of 16 varieties of garden peas tested, Ottawa 12, Onward, Wando, and Perfection W.R. produced the highest yields (2.0 to 2.2 tons of shelled peas per acre).

In the Prairie Regional Potato Trial, Pioneer and Sable varieties warranted further testing. Of 144 varieties and seedlings tested, only two were worthy of advanced testing.

Mustang, Ottawa 6, and Scotia tomato varieties produced significantly higher yields of ripe tomatoes than any of the 11 varieties in the test.

Plant mulches and protectors—Corn yields were increased by from 387 to 846 doz ears/acre for early and late varieties by the use of plastic, either as a mulch or as a cloche. The treatments also hastened maturity of the early, medium early, medium late, and late varieties by 7, 4, 2, and 6 days.

Fertilizers for corn and potatoes—Different rates and kinds of ammonium phosphate fertilizers, plus additional N, failed to affect the number of ears or yield of corn in 1967.

Whereas the results of 3 years' work showed that, on the Melfort soil, potato yields were increased significantly by up to 70 lb of P fertilizer in combination with 80 lb of N/acre, the 1967 results showed yield responses only at the lowest rate of fertilization (35 lb of P/acre) probably due to the very dry conditions. At Nipawin, a heavily manured field was used with soil analyses showing high levels of P and N. As a result, no response to added commercial fertilizer was obtained. In the past 3 years, at Nipawin, significant responses (averaging 73 cwt/acre) to P at 36 lb/acre and to K at 50 lb/acre in the presence of 160 lb N and 60 lb S/acre have been obtained. At both locations, fertilizers decreased specific gravity of the tubers and hastened tuber formation.

Apple breeding—The first phase of the Prairie Cooperative Fruit Breeding project is nearing completion. Only 590 of the original 6,900 seedlings have not fruited. Twenty-two selections have been made, of which two are being propagated for a second test.

Weed Control

Herbicides for the control of weeds in grain crops—The results of one study suggest that the rate of fertilizer and an adequate amount of the herbicide triallate properly incorporated into the soil were important in order to obtain satisfactory control of wild oats on stubble land.

Nitrofen, barban, and trifluralin were compared for broad-leaved weed control in Echo rapeseed. None of the treatments had any adverse effects on the rape yields, but weed control was variable and difficult to assess under the conditions of the test.

A study was conducted for the past 2 years on the effect of liquid (28-0-0) and granular (46-0-0) N in preseeding and postemergence treatments, alone and in combination with 2,4-D, on the yield of Conquest barley seeded on stubble. The value of the two forms of N for increasing yields was about equal. The effect of the 2,4-D in controlling weeds was not hampered when 2,4-D was applied as a mixture with liquid N.

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Research Station
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INTRODUCTION

The Research Station is the main center for research on the control of weeds in the Prairie Provinces. Other functions are cereal breeding for south central Saskatchewan, and the increasing and distributing of seed of new cereal and forage crop varieties developed by the Research Branch.

The weed control program includes agronomic, ecological, and physiological stu-

[1] On transfer of work at Weed Research Organization, Oxford, England, August 1967 to September 1968.
[2] Appointed October 23, 1967.
[3] On 2-year assignment at Plant Breeding Station, Njoro, Kenya, February 1967 to February 1969.

dies. The agronomic work is primarily directed towards the control of weeds in field crops. Ecological studies include surveys of weed populations on the prairies and the collection of information on life histories of these weeds.

The physiological weed research concerns the mode of action of herbicides. A pesticide chemist, Dr. A. E. Smith, has joined the weed section to study the residues of herbicides in soil and plants and to monitor herbicides in the atmosphere. Dormancy of weed seeds and growth and development of weeds are also being studied.

Seed of new cereal and forage crop varieties developed by the Department is increased and distributed to seed growers by the Seed Section. The Seed Section also carries out variety verification tests and maintains the Canadian genetic seed stocks for the Department.

The headquarters of the Station are located on 825 acres of land just outside the city limits on the southeast side of Regina. The laboratory is located in part of a warehouse in north Regina.

J. R. Hay
Director

WEED SCIENCE

Eradicating wild oats—In 1962 a test was set up to study the feasibility of eradicating wild oats from infested fields. The use of diallate and triallate in different rotations was supplemented by hand roguing. The production of new wild oat seed was prevented by this method and by summerfallowing for 6 consecutive years. Over 95% of the wild oats germinated within the first 2 years. During the 3rd to 5th years less than 1% emerged annually. None emerged in the 6th year. Diallate at 2 lb/acre in flax and triallate at 1.5 lb/acre in barley gave over 90% control. From 2 to 4 man-hours per acre were required to rogue out the escaped plants. To do a thorough job of roguing, the plots had to be rogued two to four times during the growing season.

Incorporation of triallate on stubble land—Tests on the incorporation of triallate in stubble confirmed the preliminary results obtained in 1966. Discing to bury trash before seeding did not increase the effectiveness of triallate. Good results were obtained when wheat was seeded directly into standing stubble with a discer and the herbicides incorporated in the usual manner by harrowing twice. In these tests there were 1,800–2,000 lb of straw per acre. Therefore, with this amount of trash, comparable results on stubble and fallow crops can be expected. For best results with triallate, the soil at the surface must be moist.

Analysis of diallate—A method of extracting diallate from soil has been developed. When measured by gas chromatography 85% was recovered from Regina heavy clay and 65% from Weyburn loam. The lower recovery in the Weyburn loam is probably due to its higher organic matter content. The sensitivity of the method is less than 0.05 ppm. This method of chemical analysis for diallate will be used to corroborate the bioassay results on microbial degradataion in the soil that were reported last year.

Degradation of herbicides—In soil, the degradation of picloram, diallate, and triallate occurred in two phases. There was a lag period before any breakdown occurred. It was during this period that induction or adaptive processes took place and after which the herbicide started to disappear. The length of the lag period was proportional to the concentration, but the breakdown occurred at a constant rate irrespective of concentration, i.e., by a first-order reaction. Therefore, in establishing values to compare the persistence of herbicides in soil, both the lag period and the k-value for the first-order reaction should be described.

Effect of dicamba on flax—In greenhouse tests, when dicamba was applied to the soil and the pots were watered from the surface so that the chemical was carried

down to the root zone, flax was injured. When the pots were watered from below the surface, the flax escaped injury. Flax was also unharmed when the soil was not treated and the chemical was applied to the foliage and stems only. This could explain the sporadic reports of injury to flax treated with dicamba in the field. When heavy rainfall occurred after application, the herbicide could injure the flax if it was carried down to the root zone of young seedlings.

Annual broad-leaved weeds—Tests on control of weeds that are resistant to 2,4-D, mainly wild buckwheat and cow cockle, were continued. Besides bromoxynil and dicamba several new chemicals gave good control of wild buckwheat. These included picloram at 0.5 oz/acre, chlorflurazole at 16 oz/acre, a 1:2 mixture of monolinuron and MCPA at 9 oz/acre, and 1:4 mixture of OCS 21799 and dicamba at 5 oz/acre.

Besides dicamba the following new herbicides or mixtures of herbicides gave satisfactory control of cow cockle: a 1:1 mixture of bromoxynil and MCPA at 8 oz/acre, mecoprop at 16 oz/acre, chlorflurazole at 12 oz/acre, fenoprop at 12 oz/acre, morfamquat at 1.0 lb/acre, and picloram at 0.5 oz/acre.

Of these chemicals, picloram injured wheat and fenoprop injured flax.

Green foxtail—The search for a satisfactory herbicide to control green foxtail in wheat was continued. In 3 years of testing, benzadox at 1 lb/acre gave at least 70% control. Each year the wheat recovered from the slight injury noted early in the season. Other compounds that showed promise were WL 9385 at 2 lb/acre, MSMA at 2 lb/acre, and SD 11831 at 4 lb/acre.

In 1967 the peak period of emergence of green foxtail on Asquith fine sandy loam near Regina occurred between June 1 and June 21. This was 3 weeks earlier than in 1966. Preliminary tests indicated that adequate moisture at the soil surface and a soil temperature of about 60 F are required for maximum germination. Also, dormancy does not appear to be as persistent in green foxtail as in wild oats.

Green foxtail was found in 150 of 407 fields surveyed in the three Prairie Provinces. In Manitoba, where it was found in 82% of 55 fields, it occurred in all soil types. In Alberta, it was present in only 25% of 83 fields and occurred only in medium- and coarse-textured soils. The reasons for the different distributions with respect to soil type in the two areas are being investigated. Densities were as high as 6,000 plants/m^2 with maximum densities being found on the coarse-textured soils. In preliminary tests, the yield of wheat was reduced by competition from 720 or more green foxtail plants per m^2.

Leafy spurge—Picloram at 1 and 2 lb/acre gave 95 and 97% control of leafy spurge on uncultivated grassland over a 2-year period. In pot tests picloram was more effective in suppressing the growth of leafy spurge when it was applied to the soil than when applied to the foliage. Foliage applications with 2,4-D added to picloram increased the top-kill, but not the root-kill. 2,4-D did not increase the action of picloram applied to the soil.

Tolerance of grasses to picloram—In the field, June grass, *Koeleria cristata* (L.) Pers., and bluegrass, *Poa pratensis* L., increased in the leafy spurge plots treated with picloram. In another test, bromegrass, *Bromus inermis* Leyss., was seriously injured by picloram applied after haying. Preliminary tests indicated that picloram persisting in the soil after treatment interferes with the establishment of certain grasses and legume seedlings. There are differences in the tolerance of seedlings of various forage species to picloram. Tests are continuing to determine if these differences are of practical significance.

Toxicity of picloram in soil—Soil organic matter, pH, and moisture all affected the herbicidal action of picloram in soil. At low pH, the unionized picloram molecules were inactivated when absorbed by the soil particles. However, when ionized, uptake of picloram by the plant decreased. This probably explains the lower activity of this herbicide in acidic and alkaline soils.

The soil moisture level affected the growth of sunflowers growing in soil containing picloram. Excess soil moisture (i.e.,

above field capacity) probably diluted the picloram in the soil solution, thereby reducing toxicity.

Leaching of picloram in columns of Regina heavy clay by 10 cm of water was considerably greater when water was supplied in increments of 2.5 cm than of 0.25 cm. The time period for applying 10 cm of water was the same in each case. Therefore, in the field, leaching would be more extensive after a heavy rain than after a series of light showers. This work is being continued to study the leaching of picloram in different soil types.

Aspen poplar—An extensive set of tests was laid out at Insinger, Sask., on control of aspen poplar, *Populus tremuloides* Michx. The area was cleared by a bulldozer in the winter of 1965–1966 and the regrowth was up to 3 ft tall at the time of treatment. The tests were designed to establish the optimum formulation, rate, type of carrier, volume of carrier, and time of application for 2,4-D. Some differences in initial kill were recorded in 1967, but the final results will not be available until 1969.

A method of propagating cuttings of aspen was developed. Six-inch sections of mature roots were placed in flats of moist vermiculite in an incubator. Shoots that developed on these root sections were excised when about 3 inches tall and set with the basal ends in nutrient solution. Roots developed in about 21 days at which time the cuttings were planted in soil. This technique will make it possible to study the action of herbicides on clonal material of this species under controlled conditions.

Weed control in tree nurseries—Competition from annual weeds did not affect the survival of white spruce, *Picea glauca* (Moench) Voss, blue spruce, *Picea pungens* Lamb., or Scots pine, *Pinus sylvestris* L., in irrigated nurseries. However, after 2 years, height, fresh weight, and stem diameter were reduced when weeds were not controlled. For optimum growth, 60% control was needed in the two species of spruce and 40% in the Scots pine.

Treatments that gave at least 70% control with no apparent effect on growth over a 2-year period were: single yearly applications of neburon at 4 lb/acre or linuron at 2 lb/acre, two applications each year of DCPA at 10 lb/acre and two directed applications each year of sodium pentachlorophenate at 15 lb/acre.

Bud development on perennial weeds—Exposure of the apex of an isolated rhizome of quack grass to light inhibited elongation of the internodes in the apical bud. With this cessation of growth at the tip, development of the lateral buds started. Exposure of lateral buds to light, however, did not affect growth.

The growth of lateral buds on short sections of rhizomes excised from the parent plant was strongly inhibited by the rhizome apex. Increasing the length of the isolated rhizome caused a reduction of apical dominance and a consequent stimulation of bud activity.

The effect of both light and length of rhizome sections on bud development was consistent with the hypothesis that the growth of the lateral buds is inhibited by competition for nutrients with the rhizome apex. Their growth is therefore greatly affected by the nutritional status of the rhizome. Since these rhizomes were supplied with high levels of N, it is assumed that competition was for carbohydrates. When growth at the tip was inhibited by light, nutrients became available for growth of the lateral buds. In the long sections, there was more than enough stored nutrients to support the growth of apical buds so that growth of lateral buds was possible.

Soluble carbohydrates in the lateral buds on the rhizome sections were measured at various times after the rhizome was detached from the parent plant. When the apex of the rhizome section was left on, the carbohydrate content of the lateral buds declined steadily and buds did not grow. When the apex was removed, the carbohydrate level in the buds increased and some lateral buds started to grow.

Further support for the role of nutrition in correlative inhibition was also observed in experiments with flax, *Linum usitatis-*

simum L. Flax seedlings were grown in sand cultures with controlled supply of mineral nutrients. If the supply of N or P was limited, the presence of the main shoot suppressed growth of buds in the axils of the cotyledons. If the main shoot was removed, the two cotyledonary buds developed, but one usually grew faster than the other and eventually the growth of the slower one stopped almost completely. These inhibiting effects were overcome if N or P supplies were not limited. Twelve hours after the removal of the dominant shoot, there was an increase in the total N content of the inhibited shoot.

The growth of buds on roots of leafy spurge was inhibited by the growing buds on the above-ground shoots. This phenomenon was also affected by internal competition for the nitrogen.

SEED SECTION

Seed distribution—Three new varieties of oats were distributed to qualified seed growers: 11,007 bu of Kelsey oats, which was licensed in 1966, to 299 seed growers in Ontario, Manitoba, and eastern Saskatchewan; 1,371 bu of Sioux oats to 28 seed growers in southwestern Saskatchewan and southern Alberta; 180 bu of Fraser oats to one grower in British Columbia, three in Alberta, and two in Saskatchewan.

In 1967, 100 Foundation wheat growers received 2,820 lb of Breeder seed of six varieties, and 54 Foundation oat growers received a total of 2,215 lb of Breeder seed of six varieties of oats. Breeder's seed of flax, fall rye, buckwheat, and sunflowers were also distributed.

A total of 1,961 lb of Breeder's seed of Orbit tall wheatgrass, Sawki Russian wild ryegrass, Redpatch bromegrass, Trader meadow fescue, and Beaver alfalfa were distributed to 19 seed growers through the Forage Seed Crop Project. Plantings of three new forage crops were established on 23 acres.

Genetic seed stocks—In 1967, 1,553 genetic lines of wheat were replenished. The Management Services Section of the Canada Department of Agriculture was consulted on the methods of information storage, data retrieval, and catalogue publication. Plans have been made to transfer the information about the genetic stocks from file cards to punch cards for computer use. This will lower the cost and facilitate information storage, data retrieval, and catalogue publication. The first catalogue of the genetic stocks in storage at Regina will be published in March 1969.

Variety verification—In 1967, 1,828 samples including wheat, oats, barley, flax, and rape were received from Plant Products Division for variety verification. About 3,000 seeds of each sample were planted in plots four rows by 34.5 ft. Fifteen samples were considered to be contaminated in excess of established tolerances.

Winter production of plant breeding material—Two acres of small plots that were seeded at the USDA Station, Brawley, Calif., in November 1966 were harvested in April and May 1967. The material, consisting of wheat, barley, flax, peas, oat hybrids, and oat species was for seven plant breeders. The production at this new location was better than in previous years and the seed sample was good to excellent.

Material for 12 plant breeders was seeded in November 1967 at Brawley. No oats were included this year, but soybeans, rape, buckwheat, and field beans were included to determine the feasibility of winter increases of these crops. Four acres of land were used including 1.2 acres for a bulk increase of a new line of durum wheat.

MANUFACTURERS OF HERBICIDES IDENTIFIED BY TRADE NAMES

If a common name has not been approved for a herbicide, the temporary designation and manufacturer are listed below.

Trade name	*Manufacturer*
benzadox	Gulf Research and Development
chlorflurazole	Fisons (Canada) Limited
DCPA	Diamond Alkali (Canada) Limited
MSMA	Niagara Branch Chemicals
morfamquat	Imperial Chemical Industries Ltd.
OCS 21799	Velsicol Corporation of Canada Limited
SD 11831	Shell Development Company
WL 9385	Shell Canada Limited

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B. P. Goplen, B.S.A., M.Sc., Ph.D.	Legumes
S. H. Pawlowski,[4] B.Sc., M.Sc.	Oilseed crops
L. G. Sonmor, B.S.A.	Irrigation
G. R. Stringam,[5] B.S., M.S., Ph.D.	Cytogenetics

Insect Bionomics and Control Section

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[1] Appointed June 16, 1967, seconded from Departmental Library.
[2] Appointed May 3, 1967.
[3] Seconded from Departmental Library.
[4] Transferred from Research Station, Lethbridge, Alta., July 1, 1967.
[5] Appointed September 12, 1967.

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H. P. W. Rostad, B.S.A.	Pedological characterization
J. A. Shields, B.S.A., M.Sc.	Pedological characterization
H. B. Stonehouse, B.S.A., M.Sc.	Pedological characterization

Plant Pathology Section

R. D. Tinline, B.A., M.Sc., Ph.D.	Head of Section Cereal root diseases
S. H. F. Chinn, B.Sc., M.Sc., Ph.D.	Soil microbiology
H. Harding,[9] B.Sc., Ph.D.	Forage legume diseases
R. W. L. Kaul, Dipl. Agr., Ph.D.	Drought physiology
R. J. Ledingham, B.Sc., M.Sc.	Cereal root diseases
G. A. Petrie,[10] B.A., M.A.	Oilseed diseases
J. D. Smith, B.Sc., M.Sc.	Forage crop diseases

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[6] Appointed September 18, 1967.
[7] On educational leave, 1966 to 1968.
[8] Appointed September 11, 1967.
[9] Appointed September 19, 1967.
[10] On educational leave, February to May 1967.

Experimental Farm, Scott, Sask.

C. H. Keys, B.S.A.	Superintendent Weeds and crop management
W. A. Russell, B.S.A.	Potato isolation
H. Ukrainetz, B.S.A.	Soil fertility

Departures

J. S. Clayton, B.S.A., M.Sc. Transferred to Soil Research Institute, Ottawa, September 1967	Head of Pedology Section
N. C. Lawson, B.Sc., N.D.A., Dipl. Agr., M.Sc., Ph.D. Resigned June 1967	Oilseed crops
B. J. Sallans, B.S.A., B.A., M.Sc., Ph.D. Retired April 22, 1967	Cereal root diseases

VISITING SCIENTISTS

Z. P. Kondra, B.S.A., M.Sc., Ph.D. Postgraduate student 1965–67	Rapeseed breeding
J. Krzymanski, M.Sc., Ph.D. Food and Agriculture Organization postdoctorate fellow 1967–68	Oilseed crops
M. Bechyně, B.Sc., Ph.D. National Research Council postdoctorate fellow 1966–68	Oilseed crops

INTRODUCTION

This report outlines the most significant results of the 1967 research. This year we are giving good coverage to some selected subjects and brief reports on others; we plan to give particular emphasis to the latter in the next annual report. In particular, rapeseed breeding, grasshoppers, shadflies, western encephalitis, cereal root rots, pedology, and soil fertility are featured this year. Details are available in journal papers and reports listed under "Publications."

In 1966, 180 acres of the Tree Nursery Station at Sutherland were transferred from the Prairie Farm Rehabilitation Administration to the Research Station. Development to make the area more suitable for experiments on crops, insects, and plant diseases has continued throughout 1967. About 6 miles of trees and hedges were removed and the land was leveled. Water and electric lines were extended to the building site, perimeter roads were constructed, and about 1 mile of fence was taken down and replaced. Initial studies confirm that the soil is extremely uniform, highly fertile, and well suited to experimental work.

J. E. R. Greenshields
Director

Oilseeds

Rapeseed—The rapeseed acreage in Western Canada has remained at the record level of 1.4 million for the past 3 years. Rapeseed now occupies over 25% of the crop land in many northern districts and is the fourth most important crop in Western Canada. The Station coordinates rapeseed trials at 33 locations in Canada and the United States.

A new strain of the Argentine type, developed at this station, produces a seed oil superior to normal rapeseed and soybean oils for the manufacture of partially hydrogenated, winterized salad oil. This oil is high in oleic acid, contains little saturated fatty acids, and is essentially free of the long-chain fatty acids eicosenoic and erucic normally found in substantial amounts in rapeseed oil. In 1965, 1966, and 1967 we undertook semicommercial increases of this strain in cooperation with the Saskatchewan Wheat Pool. Favorable results of these large-scale experiments created a market outlet for this new oil and showed that the strain can be produced commercially in a pure form. Over 10,000 acres of the strain were contract-produced in 1967, and it is expected that over 30,000 acres will be sown in 1968. All production will likely be used in the domestic market. Development of a similar zero erucic acid strain in turnip rape is under way. Studies on the fatty acid composition of other *Brassica* species disclosed that the gene for zero erucic acid occurs frequently in the weed species *Brassica kaber* (DC.) L. C. Wheeler.

Rapeseed meal contains low molecular weight sulfur compounds that may cause metabolic upsets in poultry and nonruminant animals if fed in large quantity. This problem has been largely overcome in the domestic market through new methods of seed processing. The ultimate solution is removal of these isothiocyanates and oxazolidinethione through plant breeding. With the cooperation of the Prairie Regional Laboratory of the National Research Council, a population of plants from the *B. campestris* L. varieties Echo, Arlo, and Polish was identified, which contained no oxazolidinethione or no pentenyl isothiocyanate or neither of them in their seed meals. Some plants were also identified as having low butenyl isothiocyanate. Progenies containing the desirable parental characteristics are being used to develop a turnip rape variety free of pentenyl isothiocyanate and oxazolidinethione.

A large number of selections and varieties of *B. napus* L. were also evaluated for content of sulfur compounds. All contained substantial amounts of isothiocyanates and oxazolidinethione except the summer rape variety Bronowski introduced from Poland. This variety contains only trace amounts of butenyl isothiocyanate and no pentenyl isothiocyanate or oxazolidinethione. Bronowski is not adapted to Western Canada in its present form, but selected plants will be used in breeding Canadian varieties free of these sulfur compounds.

Irrigated Crops

Crop adaptation—Saskatoon and Outlook, the test sites, are on the northern and southern extremities of the proposed irrigation area to be served by the new Gardiner Dam. Twenty varieties of field peas produced an average yield of 114 bu/acre. This was 41 bu higher than in 1966. Maximum yield of 136 bu was obtained from a Century × Stral selection. Thirty-one varieties and strains of field corn produced an average of 5.5 tons of dry matter (DM) per acre when harvested as silage September 19. This same test also produced an average yield of 100 bu/acre of grain when the cobs were harvested September 28. The highest silage yield was 7.87 tons (DM) and the highest grain yield 132 bu.

Two cuts of brome–alfalfa produced 4.7 tons (DM) of hay at both locations. Other grasses, crested wheatgrass, inter-

mediate wheatgrass, and reed canarygrass, produced almost as well (4.1 tons each) when grown with alfalfa.

Perennial Grasses

23, 33

Breeding bromegrass—Cooperative tests in Western Canada showed the S-6325 synthetic strain of bromegrass to be an excellent seed producer. In tests in Eastern and Western Canada the strain compared favorably for forage yield with other recommended varieties of the southern type. Release as a variety will be recommended in 1968. A Foundation seed increase by the Experimental Farm, Indian Head, Sask., resulted in 1,800 lb of seed. This allows immediate establishment of Certified seed fields. Release of this strain as a variety should enhance the position of Canadian bromegrass seed for export.

Reed canarygrass selected for seed retention—In tests at Saskatoon and Melfort, strain S-6982 of reed canarygrass showed excellent seed retention, whereas other varieties showed severe shattering losses. Although the strain yields 6% less forage than common reed canarygrass, this handicap should not prevent its use as a variety. Further testing of the strain will be carried out, and mass selection for seed retention and vigor will be continued. The release of this strain as a variety would encourage seed production in Canada. At present most of the seed is imported.

Legumes

19, 20, 27

Breeding of alfalfa for resistance to diseases—Combining-ability studies of forage yield and resistance to bacterial wilt suggested the desirability of some alteration of the basic clones of the variety Beaver. A half-acre Breeder plot was established in 1967 to provide Breeder seed of a reconstituted stock. Breeding for a wilt-resistant stock of Ladak required the establishment of five isolation plots of different sources of this variety. A breeding program has been started to incorporate blackstem resistance into Beaver. In addition, a synthetic strain has been developed, which combines moderate to high levels of resistance to bacterial wilt and winter crown rot. This synthetic will be assessed for disease resistance and agronomic performance at several stations.

Pollination studies—Seed was harvested from a multiclone alfalfa synthetic pure-breeding for white flowers and white seed. This seed will be used for genetic investigations and research on minimum isolation requirements for pedigreed seed production.

Breeding of sweet clover—The high-coumarin synthetics consistently yielded more forage and seed than their low-coumarin counterparts. Despite this, low-coumarin strains have quality advantages that warrant their use. A 6-acre Foundation increase of low-coumarin *Melilotus alba* Desr. produced about 3,000 lb of seed in 1967. This seed will allow establishment of a Certified seed acreage when the strain is licensed as a variety.

Cereals

Variety testing—In addition to the usual cooperative tests of varieties and plant breeders' material, varieties and strains of foreign wheats were evaluated at Saskatoon, Scott, and Outlook. Tests were designed to compare performance under irrigation and on dry land at various levels of fertility. Mexican wheats such as Pitic 62, Penjamo, Nainari 60, and Lermo Rojo, and several other strains, produced substantially higher seed yields than Manitou. The quality and economics of these wheats are being investigated. Studies on the characteristics of foreign wheats will be expanded in 1968.

5, 25

Grasshoppers

28, 29, 40

Surveys—In Saskatchewan, grasshopper numbers declined in 1967 to very low levels. Only about 74 townships were infested with economic numbers (more than 4 per sq yard), including eight with 9 to 16 per sq yard. Grain crops were only slightly damaged during the early growing season, and insecticides were used in only three or four limited areas (10–40 acres) in the province. The migratory grasshopper, *Melanoplus sanguinipes* (Fabricius), comprised 53% of all adult grasshoppers; the two-striped grasshopper, *M. bivittatus* (Say), 23%; the Packard grasshopper, *M. packardii* Scudder, 18%; and the clear-winged grasshopper, *Camnula pellucida* Scudder, 6%. Delayed oviposition in the fall of 1966 retarded embryological development, and late, prolonged hatching of eggs in the spring of 1967 contributed to general population declines. Late maturity of adults and low egg deposition in 1967 indicate continued low levels of populations in 1968.

Biology and behavior of the clear-winged grasshopper—Diapause in the egg stage was best terminated by chilling at 5 C for 70 days. In general, the rate of embryological development (excluding diapause) increased as incubation temperature increased. However, 35 C was lethal to young prediapause embryos, although postdiapause embryos tolerated it well. At subzero levels the lower the temperature the greater was the reduction of viability of embryological stages, and at −29 C all eggs were killed within 5 hr.

Migrating nymphal grasshoppers marched into the wind, but stopped when it exceeded 5 mph, or when the sun was obscured by clouds, or when the temperature dropped below 30 C. Nymphs and adults of the clear-winged grasshopper preferred to bask at ground level in open patches of vegetation rather than climb upwards into sunlight. Long-range flights of this species have not occurred in recent years, although short, milling, disoriented flights during very hot days have been observed. Parasitism by the wasp *Scelio* spp. has been negligible in Saskatchewan for the past 21 years. Predation by partridges, mice, ground squirrels, skunks, and sandhill cranes has occurred in restricted sites, whereas the fungus *Entomophthora grylli* Fres. has given widespread and effective natural control.

Hatching period of the two-striped grasshopper—In the field, the two-striped grasshopper may hatch over an extended period from early May to late July. How the hatch develops may have important implications in the development of a grasshopper outbreak. Experimental field studies have shown that the extended hatch is related to the degree of embryonic development attained by the eggs at freeze-up, as well as to the spring weather pattern. Eggs laid during the fortnight preceding each of July 15, August 18, and September 15 and 30 showed 82, 52, 30, and 0% development respectively at freeze-up; they hatched the next spring on May 16, June 6, June 22, and July 7. Hatchability was 81, 55, 20, and 1% respectively. Eggs laid earliest in the summer hatched first the next spring and more of them produced nymphs.

Previous work has shown that adult females hatched early in the season contribute substantially more to population growth by laying more eggs than those emerging later in the summer. This, with the fact that hatchability of eggs declines drastically with those laid later in the season, further stresses the importance of early hatching and consequently early maturing of adults in population buildups of grasshoppers.

Measurements of soil temperature above developmental zero of the eggs (55 F), during the periods the eggs remain in the ground in autumn and the next spring, indicated that the average heat requirement of the eggs of this species under field conditions was 741 degree-days. Eggs laid during the first half of August experienced 527 degree-days before freeze-up, and 261 the next spring before hatching. Eggs laid from the middle to the end of September were exposed to 51 degree-days before freeze-up and 735 the next spring.

Diurnal hatching patterns depended on the daily temperature regime. The first hatch usually occurred between 0830 and 0930 hr when soil temperatures exceeded 70 F, but the bulk of the hatchlings usually emerged in the afternoon as temperatures rose to 90 F or higher. During unsettled weather hatching was often interrupted by clouds or light showers, but resumed again when clearing took place.

Wireworms

7, 8

Time for egg development and water absorption—Water absorption curves of eggs of *Ctenicera destructor* (Brown) at 25, 20, and 15 C were fitted to a logistic model. Water absorption began about 40 hr after oviposition. The time required from oviposition to the 50% absorption level, and the duration of 95% of the total absorption (the time between the 2.5 and 97.5% absorption levels) were determined from the fitted curves. The total development period, taken as the time from oviposition until 50% hatch, was 330.8 (329.4–332.3), 536.6 (534.4–538.9), and 1,241.8 (1,238.6–1,245.2) hr at 25, 20, and 15 C respectively. The age of eggs at the 50% absorption level was 48.5, 74.4, and 153.9 hr at 25, 20, and 15 C. The time required to reach the 50% absorption level and duration of 95% of total absorption represented 13 and 5%, respectively, of the total development period at any of the temperatures used. Water absorption therefore depended directly on metabolic rate.

Duration of the absorption period in *C. destructor* eggs appears to be considerably shorter than values reported for other species of Coleoptera. A short absorption period is considered to be advantageous for survival of eggs in soil where frequent fluctuations of moisture levels may occur.

Biological control—Soil infested with the entomogenous fungus *Metarrhizium anisopliae* (Metch.) Sor. in which successive populations of larvae of the sugarbeet wireworm, *Limonius californicus* (Mann.), were confined was still infective after 4 years. The soil was subjected to a natural environment; it was placed in nylon sharkskin bags that were buried in a field in Saskatchewan. Populations of larvae were replaced semiannually.

Natural mortality was higher during winter and spring (about November to June), averaging 32%, than during summer and fall, when it averaged 21%. *M. anisopliae* caused a two- to four-fold increase in larval mortality during summer and fall, and had no appreciable effect during winter and spring. Highest mortality always occurred in the population first confined in infected soil. In subsequent years, mortality of the larvae in infected soil occurred at a fairly constant level.

Pollinators

The alfalfa leaf-cutter bee—In spite of an apparent preference for sweet clover bloom to that of alfalfa, females of the alfalfa leaf-cutter bee, *Megachile rotundata* Fabr., consistently confined foraging to the alfalfa field where nests were located if the nesting locations were more than 40 yards from sweet clover, and alfalfa bloom was abundant when the bees were set out. But in a field where emerging bees were set out before alfalfa bloom was abundant, percentages of sweet clover pollen ranged from 96.8 in nests 35 yards from the sweet clover to 23.5 in nests 150 yards from it. Where nesting enclosures were set out in alfalfa bloom 2 to 3 yards from sweet clover, the number of bees foraging sweet clover greatly exceeded that foraging alfalfa.

Shadflies

17

Control—During the planning stages for Expo 67 the need to control dense swarms of shadflies (Trichoptera and other aquatic insects) that plagued the area was recognized. The Federal Government accepted responsibility for directing a research program, and in 1965 a river specialist was seconded from the Research Station at Saskatoon to Expo 67 Department of Installations, Montreal, to direct the abatement phase of the research. Results of this research and operational program were excellent, and shadflies were not a nuisance to visitors to Expo 67.

Abatement was achieved with four 6.0 ppm/min dosages of Rhothane[11] to the St. Lawrence River, one on each of May 5, June 13, July 10, and August 7, 1967. On the average, these treatments reduced populations of Trichoptera larvae to 2.0%, all insect larvae to 5.0%, and noninsect species to 31% of contemporary populations in an untreated area immediately upstream. The larvae of net-spinning species were more sensitive than those of case-bearing species. Of the noninsect species, crustaceans were relatively sensitive, but their populations recovered rapidly, presumably because of immigration. Molluscs were relatively tolerant, and between late May and late August their populations increased in the treated area by a factor of 550, compared with 8 in the untreated area. Separate tests showed that dosages of at least 200 ppm/min were required before native species of 1- to 2-month-old fish began to die.

The average nightly volume of shadflies collected throughout the summer in a light trap on St. Helen's Island was 98 ml in 1967, 161 in 1966 (despite two 6.5 ppm/min applications of Rhothane to the river that succeeded in eliminating most local larvae in July and August), 195 in 1965, and 361 in 1964.

A Montreal biological consulting firm and the Department of Chemistry, St. Dunstan's University, Charlottetown, P.E.I., cooperated in the collection and analysis of water, soil, and biological materials for residues.

Western Encephalitis

21

Studies on the ecology and epidemiology of western encephalitis (WE) were conducted in cooperation with the Biology Department and the Western College of Veterinary Medicine of the University of Saskatchewan, and with the provincial laboratories of the Saskatchewan Department of Health and Public Welfare. Because field work does not end until October, and analysis of current studies is incomplete, the report deals mainly with 1966 data.

Mosquito abundance in relation to weather—The influence of weather on mosquito abundance continued to receive attention. The study area is the agricultural region of the province, which extends from lat 49° N to lat 53° 30′ N and includes about 90,000 sq miles. Weather in this area is by no means uniform since it includes three climatic zones, hence a description of the weather for the whole area can be summarized only in general or average terms. The summer of 1966 was warm, and precipitation generally was slightly above normal. This produced the second largest mosquito population encountered in 4 years and caused considerable annoyance throughout the summer. The annoyance was attributable to large numbers of pest species of *Aedes* that were the dominant species in the mosquito populations of the province. Of most significance in the epidemiology of WE, however, was the relative scarcity in 1966 of *Culex tarsalis* Coquillett and *Culiseta inornata* (Williston), which formed only 1 and 14.6% of the total combined trap catches for the season, compared with 2.7 to 6.1% for *C. tarsalis,* and 15.6 to 52.5% for *C. inornata* in the preceding 3 years.

The relationship between mean weekly temperatures and population curves of *C. tarsalis* and *C. inornata* was found to hold even at the relatively low population levels of these species in 1966. Two epidemics (in 1963 and 1965) of WE in Saskatchewan have been associated with large populations of *C. tarsalis* and *C. inornata.* Data collected over the past 5 years are being analyzed to determine whether factors present in the early part of the season might affect subsequent population growth of these two species.

Aedes melanimon Dyar, a known vector of the WE virus in the United States, has been found for the first time in Saskatchewan, in the Swift Current – Maple Creek area.

Vectors of the arthropod-borne encephalitides—Changes were made in procedures of handling mosquitoes to help reduce loss of titer of virus in stored infected mosquitoes. Soon after they were identified, the living mosquitoes were ground in the suspension medium and centrifuged, and the supernatant was stored in screw-cap vials in a mechanical freezer. This procedure was also faster than transferring whole mosquitoes to ampoules and avoided the use of dry ice.

[11] Rohm and Haas Company.

Of the mosquitoes taken in catches during the 1966 season, 31,243 females, representing 19 species, were distributed in 1,156 species pools. Twenty-nine isolations of WE virus were obtained from nine species. This is the largest number of WE virus isolations obtained to date in a season, but the distribution of isolations among the species tested was as expected in a nonepidemic year in that only 5 of the 29 isolations were from *C. tarsalis*. Three of the isolations were from single mosquitoes and three from mosquitoes in pools containing only two each.

Regardless of the method by which mosquito infection rates for 1966 were calculated, they were very high for a nonepidemic season. Related studies showed that there was considerable transmission to hosts other than man, horses, domestic poultry, and house sparrows (the hosts concerned during an epidemic season), but some of the infected mosquitoes might also have had titers too low to transmit.

Nutrition

14, 15, 16

Saw-toothed grain beetle—Continuing studies of the quantitative dietary requirements of the saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus), for amino acids showed that dietary serine may be omitted from the diet without detriment to rate of growth or survival. Present indications support maintenance of the arginine content of the holidic diet for this insect at the concentration now in use, and the inclusion of L-proline at a concentration of 0.7 mg/g. Trytophan is an essential dietary component, the liminal concentration occurring between 0.2 and 0.5 mg/g. Quantitative requirements for L-histidine are now under investigation.

Insecticide Residue Studies

9, 26, 30, 31, 32, 38

Analytical methods—Several methods for the extraction of aged dieldrin residues from soil were studied by use of dieldrin C^{14}. Five commonly used methods gave between 58 and 79% recovery of residues. A method that has an extraction efficiency of 99% was developed.

Residues in plants and soils—In a survey of 20 fields of sweet clover or alfalfa in northeastern Saskatchewan 80% had dieldrin in the soil and associated plant samples. Except for a few instances the residue level was close to 0.01 ppm in plants and 0.05 ppm in soil. Residues of heptachlor, heptachlor epoxide, aldrin, or endrin, but not DDT, were encountered in a limited number of cases only. Eight weekly tillage operations in 1967 of soil treated in 1965 with aldrin or endrin reduced the residue content by 15 to 25% compared with 10 to 15% with only two tillage operations. Residues of endrin applied to wheat seedlings at 2, 4, and 8 oz/acre decreased by 99% after 2 weeks, but were still detectable after 6 weeks. At harvest no endrin was detected in the grain or straw, but an unidentified compound was detected in the straw; soil contained 0.005–0.01 ppm.

PEDOLOGY

Soil Characterization

36

Potassium release from primary minerals—Potassium release characteristics for phlogopite, biotite, muscovite, microcline, and orthoclase were studied as a function of pH. The K release in the pH range of normal soils was in the following decreasing order: phlogopite, biotite, muscovite, microcline, and orthoclase. Differences in K release between micas and feldspars increased as pH decreased. The order of decreasing K release below pH 2 was biotite, phlogopite, muscovite, microcline, and orthoclase. Varying amounts of K released between the micas and the feldspars are explainable in terms of solubilities, oxidation potentials, atomic bonding, and crystal structure.

Characterization of carbonate minerals of calcareous horizons—The carbonate content of a number of calcareous soils

was measured and characterized. The carbonate mineral fractions ranged from 60 to 75% dolomite in the glacial till soils and from 45 to 85% in the lacustrine soils. In the mineral fractions it was shown that secondary carbonates accumulated mainly in the fine silt and clay fractions. Calcite-to-dolomite ratios were higher in the Cca horizons than in the parent material.

Water-soluble salts in the parent materials of Solonetzic and Chernozemic soils in Saskatchewan—Soil profiles developed from saline parent materials may be classified in either the Chernozemic or the Solonetzic order. The water-soluble salts in the saline parent materials on which the Chernozemic soils were developed contained less than 40% sodium, but those in the parent materials of Solonetzic soils contained more than 40% sodium.

Salt dust contamination—Growth chamber experiments conducted under high moisture stress showed that wheat yields were not reduced significantly until more than 1 ton/acre of dust was added to the soil. Similar experiments conducted under low moisture stress showed that yield reductions occurred only after more than 2 tons/acre of dust were added. Field experiments conducted during a year of limited rainfall showed that wheat yields were not reduced after salt dust was mixed in the top 3 inches of soil at rates up to 5 tons/acre.

Characterization of the organic matter of Ap horizons—The composition and nature of the organic matter from Chernozemic Black soils differed distinctly from that of Gray Wooded soils. The Black soils contained larger amounts of humic acids than fulvic acids; the opposite was true for the Gray Wooded soils. The humic acids of the Chernozem displayed a narrow E4:E6 ratio indicative of a relatively high degree of condensation of the aromatic nucleus; corresponding ratios for the Gray Wooded humic acids were distinctly wider. There were indications that about half the humic acids from Chernozems were bonded to calcium, whereas those of the Gray Wooded soils were predominantly free or bonded to nonsilicate forms of sesquioxides.

Methods of measuring soil pH—The soil pH of 633 samples, representative of the main soil zones of Saskatchewan, was determined by the soil paste and 0.01 M $CaCl_2$ procedures. The average pH of the samples measured by the 0.01 M $CaCl_2$ method was only 0.4 unit less than by the soil paste method. There was no apparent relationship between decrease in pH and soil texture. The soil paste method for determining pH was retained as the standard procedure. However, the $CaCl_2$ method is used for special projects.

Reconnaissance Soil Surveys

3, 4, 34, 37

Soil classification—The main activities included establishment of new soil associations and mapping units for the current surveys of the Saskatoon and Hudson Bay map sheets and Indian reserves. The detailed soil survey of the final 391,000 acres of the Saskatoon Sheet (73B) was completed, and the preliminary map and working legend were prepared. In the Hudson Bay Sheet (63D) 250,000 acres have been mapped and sampling has been started. The Willow Bunch Sheet (72H), including 4 million acres, was completed and published. The final draft of the Rosetown Sheet (72O) map is being printed and first draft of the accompanying report describing the soils has been prepared. About 559,000 acres within 50 Indian reserves were surveyed and checked, and map legends were prepared. All the reserves within the agricultural area of the province have now been mapped and reports prepared for those surveyed before 1967. Approximately 100,000 acres were surveyed around the new potash mines in the Colonsay and Viscount areas. About 2,000 samples were taken in order to establish bench marks to periodically check the level of possible potash dust contamination from the refineries that will soon be in operation. Four other mine sites have been similarly sampled, and the reports were published in 1967.

Canada Land Inventory

1, 2

Soil capability and land use studies—Soil capability maps and area descriptions required by the Canada Land Inventory were prepared for a number of map sheet areas; maps have now been completed for the entire area within the agricultural region. Soil capability and land utilization brochures were prepared for the 299 rural municipalities and 11 local improvement districts in response to a request from the provincial government. An inventory of the capability classes within the various soil associations and textural class was also prepared.

PLANT DISEASES AND PLANT PHYSIOLOGY

Root Diseases of Cereals

10, 11, 12, 24

Selection for resistance—Single plant lines of wheat from crosses and from the USDA World Collection of Small Grains were assessed at three field locations for their reaction to common root rot caused by *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur. Wide differences in reaction were noted. A few lines were significantly more susceptible than Cypress and some were apparently more resistant than Manitou. Differences between sibling sublines in the F_5 and F_6 generations indicated segregation in the F_4 lines for beardedness, and resistance to stem rust and common root rot.

In tests at various field locations, barley lines showed fairly consistent reactions to common root rot. The reactions of sublines were more similar than were the reactions of lines from the same family. Although no lines were significantly more susceptible than Olli, or more resistant than Conquest and Parkland, the results further indicate the feasibility of breeding for resistance to *C. sativus* in barley.

Seed treatment—Proprietary fungicides applied to four wheat and four barley varieties, including the most susceptible and resistant of the commonly grown varieties, had little influence on common root rot disease and yields of grain. Natural inoculum was relied on to cause disease. In greenhouse tests, plants grown from treated seed in *C. sativus*-infested soil showed no significant reductions in disease regardless of time of sampling.

Herbicides—In a greenhouse test, 2,4-D amine applied to plants only and to soil only, at greater than the recommended rate, induced growth abnormalities, but had no effect on common root rot.

Variation in the pathogen—Isolates of *C. sativus* differed in virulence, but pathogenic races that could attack wheat varieties differentially were not found. Twenty-four single-spore isolates, obtained from the resistant wheat lines 680 and 1639 grown at 13 and 11 locations respectively, were tested for their pathogenicity to each of two resistant and two susceptible varieties in soil in greenhouse experiments. Isolates were highly significant for disease and dry weight of plants; interactions between isolates and varieties were nonsignificant.

Crop residues—The influence of the increasing acreage of stubble wheat on common root rot requires further resolution. In 1967, tests were conducted on wheat stubble land at five locations in Saskatchewan. Some plots had all straw and stubble removed; others had chopped wheat straw (2 tons/acre) added; others were untreated. Since N deficiency is likely when considerable amounts of crop residues are cultivated into the soil, N at two levels (30 and 60 lb/acre) was applied to appropriate plots. Subsequently, all plots were uniformly cultivated with either a rotary cultivator or double disc, and then seeded to wheat.

Emergence was reduced significantly as a result of the incorporation of residues at two locations, whereas it was improved in the heavy Regina soil, which was quite moist at planting time. No differences were recorded at the other stations. The N applications generally had little or no influence on emergence.

Disease ratings were reduced slightly or not at all at three locations as a result of the residues, and at the other two locations there was a reduction, significant at the 1% level. Data from all five stations analyzed as a unit showed a highly significant reduction in disease in the straw and stubble plots compared with those from which the residues had been removed. The effect of N was variable, but generally it caused a significant increase in common root rot.

At one location a significantly higher yield was recorded in the plots from which residues had been removed than in those where they were incorporated into the soil. At this location N increased common root rot. For the experiment as a whole neither crop residues nor N fertilization had a significant influence on yield.

Soil microbiology—A titratable method that uses ascorbic acid was developed to quantitatively compare fungistatic levels of soils. The method was based on the hypothesis that ascorbic acid neutralizes fungistatic substances, and that although toxic at low concentrations to spores of *C. sativus,* it has a higher affinity for the substances than for the spores. Progressive amounts of the acid were added to soil until nearly 100% of the spores germinated. Slight addition above this end point caused a sharp decrease in germination percentage. The end points were usually lower in light soils than in heavy soils. The results agree with the soil-dilution method for estimating degree of soil fungistasis.

Treatment of *C. sativus*-infested soil with methylmercury dicyandiamide at a dosage as low as 5 ppm controlled common root rot in most tests and increased yields of wheat seedlings. Since the chemical at this rate was not fungitoxic and contributed only slightly to the fungistatic titer of the soil, its role in disease control may be indirect. A marked increase in numbers of penicillia was noted in treated soils. Possibly antibiotics produced by the penicillia were effective in protecting plants from *C. sativus.* Five isolates of *Penicillium* provided similar control of *C. sativus,* but only two of the isolates afforded some protection against *Fusarium culmorum* (W. G. Sm.) Sacc. The mechanism that contributes to increased yield of wheat seedlings is unknown.

Diseases of Grasses and Oilseeds

33

Diseases of smooth bromegrass—Surveys have shown that *Selenophoma bromigena* (Sacc.) Sprague & Johnson is the most common leaf spot pathogen of smooth bromegrass, *Bromus inermis* Leyss., in the Brown and Dark Brown soil zones in Saskatchewan and Alberta, and in the Peace River area. The leaf spot caused by *Pyrenophora bromi* (Died.) Drechsl. predominates on smooth bromegrass in the Black, transition, and Gray soil zones in these regions. Southern-adapted bromegrasses have shown more resistance to *S. bromigena* and *P. bromi* than northern-adapted strains. Some introduced *Bromus* spp. have shown considerably more resistance to *P. bromi* than smooth bromegrass has.

Blackleg of rape and other crucifers—The sexual stage of the blackleg fungus, *Leptosphaeria maculans* (Desm.) Ces. & de Not., was collected in May and June 1967 on stems of *Thlaspi arvense* L. from two locations at Saskatoon. Single ascospore isolations made from this material gave rise to cultures typical of the *Thlaspi* strain of *Plenodomus lingam* (Tode ex Fr.) Hohn. in pathogenicity and cultural appearance.

Drought Resistance in Cereals

22

Wheat varieties—Differences in suction forces and osmotic pressures among six varieties of different climatic origin were not found in field tests. All varieties exhibited increased suction forces and osmotic pressures with increasing water shortage. On the lighter soils, suction forces finally exceeded osmotic pressures so that turgors became negative. Surprisingly, no signs of wilting accompanied the negative turgors. On a heavy clay soil, readings of suction force and osmotic pressure did not reach the high levels found on light soils and turgors remained positive. This indicates that a heavy clay can buffer the water status of wheat plants, providing better conditions for crop development.

EXPERIMENTAL FARM, SCOTT

Soil Fertility

Crop Fertilization

Rates of seeding and row spacing for wheat—On Scott loam under relatively favorable moisture conditions, fertilized at 60 lb of 11-48-0 and at seeding rates of 20 to 120 lb/acre, in 20-lb increments, the highest yields and increases from phosphate fertilizer were obtained at the 60- and 80-lb seeding rates. A comparison of 4.5- and 9-inch row spacings showed that the wheat yields were 14% higher at the 4.5-inch spacing.

Fertilizers for cereal crops on fallow soils—On soils with a medium amount of available P, there was an obvious response to applied P up to the heading–flowering stage. The differences in appearance between fertilized and nonfertilized wheat and barley diminished somewhat from this stage to maturity, and increases in grain yield were lower than expected. On soils testing low in available P the large observable responses to applied P carried through to maturity, and yield increases were substantial. Phosphate fertilizers were considerably more efficient for wheat when drilled with the seed than when broadcast with or without incorporation. At equal rates of applied P, the polyphosphate 15-60-0 produced yields of wheat equal to 11-48-0 on Scott loam.

Fertilizers for cereal crops on stubble land—In the spring of 1967 most soils in west central and northwestern Saskatchewan were very deficient in available N, and required applications of up to 40 lb/acre or more of N for maximum yields of wheat and barley. With adequate seedbed moisture in most soil types at seeding time, application of 40 lb/acre of N with the seed had no observable or measured harmful effects on germination and seedling emergence of wheat and barley, and yields were similar with broadcast applications. Urea and ammonium nitrate were equally effective.

Effectiveness of residual fertilizer phosphorus for wheat—Where relatively high rates of phosphate fertilizers were applied to wheat on permanent plots for 3 or 4 successive years, the available ($NaHCO_3$-extractable) P in the soil was substantially higher than in check plots in the spring of 1967. Yields of wheat were increased by the residual fertilizer P in 1967. However, even on plots that showed very high levels of residual available P, the yields of wheat were significantly increased by additional P fertilizer treatments. Apparently the residual fertilizer P was not sufficiently "available" to wheat to supply its total requirements.

Fertilizers for wheat following fertilized forage crops—Where N, P, and K fertilizers were applied once annually at various rates for several years to bromegrass and bromegrass–alfalfa on two soil types, the yields of a following wheat crop were increased only by residual fertilizer P. For maximum yields of wheat in the 1st year on the grass sod, N and P fertilizers were required.

Fertilizers for bromegrass—Large increases in yields of bromegrass hay and seed were obtained from applications of N fertilizers to an old established stand on Scott loam in 1967. Significantly higher seed yields resulted from fall-applied N and P than from spring applications. Periodic examinations of bromegrass plants indicated that flower primordia are initiated in early spring. The availability of fertilizer from fall applications hastens and increases primordia development.

Broadcast applications of phosphate fertilizers resulted in smaller increases in yields of bromegrass than did N fertilizers. Phosphate was somewhat more effective when placed 3 to 6 inches deep with a chisel applicator than when broadcast on the surface. The chiseling treatment without fertilizer substantially increased seed yields.

Response of wheat and barley to lime applications on Scott loam—Liming treatments applied 2 and 3 years ago on acid Scott loam were still effective in 1967 and increased the yields of wheat and barley substantially. Additional treatments were applied on new plots in 1967, and laboratory studies are continuing to determine

what soil factors are influenced by lime applications.

Soil Chemistry

Effect of soil aggregate size on nitrification—Samples of Scott loam (Dark Brown) and Loon River loam (Gray Wooded) were subdivided into several size fractions by sieving, and incubated at constant temperatures to determine rates of nitrification.

At 10 C, nitrification of ammonium sulfate was inhibited most in the finest fractions of both soils. However, at 25 C particle size had no influence on nitrification rate. Nitrification began earlier and proceeded slightly more rapidly at low and high moisture contents in the Scott loam. At 25 C or above, the rate of mineralization of a given source of nitrogen appears adequate in Loon River loam, and poor soil structure is not a factor. However, the low available-nitrogen levels usually found in this soil are probably related to low soil temperatures and low organic matter content.

Effect of drying soil samples on $NaHCO_3$-extractable phosphorus — The amount of $NaHCO_3$-extractable P measured in soil samples was influenced by the method of drying, and the effect of drying varied with soil type. In most soils the extracted P levels increased as air drying progressed, and large increases occurred in some soils when oven-dried at 80 or 105 C before extraction.

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Swift Current, Saskatchewan

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INTRODUCTION

Research to improve and stabilize agriculture under conditions of limited moisture has been a major objective of the Research Station at Swift Current since its establishment in 1921. It serves the main wheat-producing region of Canada.

In 1967 the research program was expanded by the appointment of plant physiologists to intensify fundamental research on response of plants to environment; new positions were provided to expand and intensify wheat breeding; research in soil fertility, soil moisture, plant nutrition, and crop ecology were intensified to provide fundamental information basic to more precise recommendations for fertilizer application, better moisture utilization, and crop management. Two new scientists were appointed to continue research on turkey nutrition.

This report summarizes research completed and progress on long-term projects during 1967. It does not refer to all research in progress nor to new projects established during the year. Further details may be obtained from publications listed, reprints of which are generally available from the authors.

J. E. Andrews
Director

[5] On transfer of work at Welsh Plant Breeding Station, Aberystwyth, Wales, July 1967.
[6] Appointed October 23, 1967.
[7] Appointed July 20, 1967.

CLIMATE

The climate of southwestern Saskatchewan is semiarid, and low precipitation is often the main factor limiting crop production. Low precipitation in 1967 aroused fears of crop failure, but an average crop was produced. This was probably the result of the favorable interaction of a number of environmental factors, some of which would normally be considered unfavorable to high production.

Precipitation in the fall of 1966 and during the first 4 months of 1967 was above average, providing good soil moisture reserves. During the growing season of May, June, and July, precipitation was only 1.7 inches in numerous light showers compared with a longtime average of 6.2 inches. Although average air and soil temperatures were below normal in April and May, they were about normal from June to September. Night temperatures were low in June and a frost occurred in July for the first time on record at Swift Current. It damaged potatoes and vegetables in localized areas, but not the wheat crop.

Sunshine was above average during the summer, and the 403 hr recorded in July established a new record at Swift Current. Winds were slightly above average in July. These two factors produced high evaporation rates.

ANIMAL AND PASTURE SCIENCE

Range and Pasture Management

Russian wild ryegrass for early winter grazing—Pastures sown to Russian wild ryegrass, *Elymus junceus* Fisch., in 8-, 16-, and 24-inch rows produced enough herbage for 42 pasture days when grazed at 0.29 and 0.37 ha/animal unit month (AUM) by 800-lb heifers during October and November from 1964 through 1966.

In 1967, the 8-inch seeding grazed at 0.29 ha/AUM provided herbage for only 28 days. The 8-inch seeding grazed at 0.37 ha/AUM and the 16-inch seeding pastured at 0.29 ha/AUM produced enough herbage for 38 days. The 16-inch seeding grazed at 0.37 ha/AUM and the 24-inch seeding grazed at both rates provided enough herbage for 42 pasture days.

Evaluation of Altai wild ryegrass and green needlegrass—Altai wild ryegrass, *Elymus angustus* Trin.; green needlegrass, *Stipa viridula* Trin. var. Green Stipa; and Russian wild ryegrass were sown in 36-inch rows in May 1966. Seed was harvested in July and the aftermath grazed during September and October 1967. Seed yields were: Altai wild ryegrass 80 kg/ha, green needlegrass 260, and Russian wild ryegrass 290. The aftermath was grazed to a 4-inch stubble by 800-lb steers. Liveweight gains were: green needlegrass 30 kg/ha, and Altai and Russian wild ryegrasses 60.

A classification of Fescue grasslands—Three alliances of the order Festuceto-Stipetalia were described and the areas of each delineated. The Danthonion parryi alliance occurs in the foothills of the Rocky Mountains at elevations between about 1,000 and 2,000 m, and extends northward from the International Boundary to near the Bow River. The alliance Festucion scabrellae was found at similar elevations in the Cypress Hills, the Wood, Duck, and Riding mountains, northward from the Bow River in the foothills of the Rocky Mountains, and discontinuously in the Parkland. The Agropyreto–Festucion scabrellae alliance was delineated in south central British Columbia at altitudes of over 1,000 m. Ecologically, the three alliances represent grasslands of dry-mesic to moist soils of relatively low fertility in subalpine and subarctic regions. The annual increment of either hay or pasture seldom exceeds 1,000 kg/ha.

The effects of climate and soil on species distribution—Plants of several native species have been collected from widely scattered locations and established in a uniform nursery. Studies are under way to classify the association of the phenotypes with environmental factors.

Phenotypes of stinkweed—The progeny of annual and winter annual phenotypes of stinkweed, *Thlaspi arvense* L., produced the growth forms of their parents only when the parent plants were grown to maturity at constant temperatures of 20 and 12 C, and when their seed was stored at −12 C for 7 months. In the greenhouse the annual phenotype flowered within 45 days after planting, but the winter annual required 100 days. Seed from the earliest maturing pods required fewer days to mature than that from later maturing pods. Though the overall germination of seed from one plant was usually high—up to 90%—the seed from later maturing pods often germinated poorly.

Turkey Nutrition

Rapeseed oil in starter diets—Male poults fed rapeseed oil alone or in mixtures with low levels of soybean oil grew less and consumed more feed than those fed a basic ration to which soybean oil alone or not more than two-thirds rapeseed oil was added. Low levels of beef tallow were more effective than soybean oil in overcoming the growth-retarding effect of rapeseed oil. Poults 4 weeks old or over made better use of rapeseed oil than younger birds. The metabolizable energy (ME) values of diets containing 9% rapeseed or soybean oil were 2.76 and 2.95 kcal/g respectively when the poults were 2 weeks old. But when the poults were 6 weeks old, the ME values of the same diets were 2.95 and 3.0 kcal/g for rapeseed and soybean oil.

Male meat-strain chicks fed a 10% soybean oil diet grew faster than chicks fed a 10% rapeseed oil diet, or a diet that contained 2.5, 5, or 7.5% rapeseed oil with 7.5, 5, or 2.5% soybean oil respectively.

Relationship between dietary and depot fats—Depot fat of 6-week-old male poults was nearly identical with the fatty-acid composition of the dietary fat. A decrease of about 20% in erucic acid content of the depot fat from that of the dietary fat was offset by an increase of about 20% in eicosenoic acid.

The same diet fed to male meat-strain chicks for 6 weeks resulted in marked changes of dietary and depot fats. Erucic acid decreased by 50%, and linoleic and linolenic acid contents dropped slightly. There was no change in eicosenoic acid. There were increases of palmitic, palmitoleic, stearic, and oleic acids in the depot fat but not in the dietary fat.

Forage Evaluation

In vitro digestion (2)—For practical purposes fermentations of 24-, 48-, and 96-hr duration allowed us to predict in vivo digestibility directly from in vitro fermentation for high-, medium-, and low-quality alfalfa, bromegrass, and Russian wild ryegrass. A 48-hr fermentation period achieved the same purpose for all qualities of crested wheatgrass and reed canarygrass. When 12 alfalfas and 24 grasses were grouped, a 48-hr fermentation gave the best results; in vitro digestibility accounted for 92% of the variability observed in in vivo digestibility.

The voluntary intake of alfalfa and grass hay decreased by 1.11 g and 1.31 g respectively with each percentage-point decline of in vitro digestibility; voluntary intake was measured as grams of digestible organic matter (DOM) per kilogram of metabolic size of sheep. All crops were consumed in about equal amounts when their in vitro digestibility exceeded 71%. Voluntary intake provided enough nutrients for maintenance only when in vitro digestibility was 50 to 60%; at digestibilities of 75 to 80%, intake sufficed for twice the maintenance level.

The in vitro digestibilities of immature alfalfa and grass hays were the same when they were ground through 0.5- or 2-mm screen. But as maturity progressed the digestibility of the more finely ground (0.5-mm) forage decreased at a slower rate than that of the coarsely ground (2-mm) forage. With each percentage-point increase in the difference of in vitro digestibility, the voluntary daily intake of alfalfa and grass hays declined by 2.3 and 4.2 g respectively per kilogram of metabolic size of sheep.

Quality-rating systems for hay (29)—The quality of six hays harvested at six maturity stages was estimated more accurately by in vitro digestibility than by 11 other quality-rating systems. The nutritional value of each hay was determined by the daily voluntary intake of grams of

DOM per kilogram of the metabolic size of four sheep. This was correlated with each of 12 quality-rating systems by simple or multiple linear regressions; the coefficients of variation from regression indicated the relative precision of each system. Coefficients varied widely between systems and for different crops within systems.

Passage of digesta (28)—The voluntary intake of hay by wethers was related to the size and shape of digesta particles passing the reticulo-omasal orifice. That fraction of the digesta retained by a 0.25-mm screen was selected as a measure of "relative particle size" to differentiate between maturity stages of grasses and alfalfas. The "relative particle size" of omasal digesta of the same crop increased as maturity advanced and voluntary intake declined, whereas that of different crops at the same stage of maturity increased with increasing voluntary intake.

The highest correlations between voluntary intake of hay and its physical breakdown were obtained after 30 min of artificial mastication. The fraction passing a 0.25-mm screen was the criterion of physical breakdown. A one-percentage-point increase in physical breakdown was associated with an increased daily voluntary intake of 1.02 g of dry matter per kilogram of metabolic size of sheep. Extrapolations of regressions suggest that when physical breakdown is zero, intake is zero also.

ENGINEERING SCIENCE

Irrigation

Advection (13)—The effect of advected energy on irrigated areas that are considerably smaller than the surrounding dry land is an important consideration in scheduling irrigations.

Sites were set up outside of and at varying distances within an irrigated field of alfalfa to measure temperature and evaporation above the crop and evapotranspiration from the crop. Evapotranspiration was measured by lysimeters each day and by the neutron method once a week.

The conclusions reached from 1 year's results are as follows: The temperature over alfalfa on the irrigated field was 9 F lower than over the same crop on the dryland border on sunny days, whereas the reduction was only 2 degrees on cloudy days. The evaporation over the irrigated crop was 0.2 inch or 20% less than over the dryland border on sunny days, whereas the depression was slight to negligible on cloudy days. The distance that advection extended into the irrigated area varied from 40 to 280 ft on bright sunny days, 120 ft being the most frequent. The variation in temperature and evaporation from day to day is an important factor in this area. Daily extremes can become marked because of variable wind conditions and cloudy, rainy days. Evapotranspiration, therefore, must be measured each day in order to evaluate adequately the effect of advection on irrigation scheduling.

Soil sterilants for maintaining irrigation ditches—Examination, late in the fall of 1967, of irrigation ditches sprayed with simazine, atrazine, monuron, diuron, Calmix,[8] or bromacil at 20, 40, or 80 lb/acre during the fall of 1965 indicated the following: The effectiveness of the various sterilants was satisfactory and quite similar. Bromacil was slightly superior and diuron slightly inferior to simazine, atrazine, and monuron. The low rate of application of 20 lb/acre was noticeably inferior in effectiveness of kill. The high rate of application of 80 lb/acre did not control deep-rooted plants such as dandelion, alfalfa, and rose bushes. A 40-lb/acre rate of application of simazine, atrazine, monuron, and diuron was as effective as the 80-lb rate. Isolated instances of sterilant moving from the ditch to the field and sterilizing the soil in the vicinity of the turnout from the irrigation ditch was noted and verified by analysis

[8] Calmix Maintenance Weed and Grass Killer, a mixture of monuron, TCA, and 2,4-D. Allied Chemical Services Ltd., Calgary, Alta.

in the greenhouse. There is an indication of greater field damage from simazine. Control was effective for at least 3 years when the ditch was clean at time of spraying, but for a doubtful 3 years when the ditch was weedy.

Soil and Water Conservation

Watershed hydrology (20)—On a watershed at Swift Current, Sask., 140 acres in size, established in 1947, and one at Davin, Sask., 3,000 acres in size, established in 1950, runoff from snow and rain each year was compared. The volumes differed although the amounts of precipitation were similar. Runoff volumes (acre inches per acre) for the larger watershed were generally higher; runoff from snow accounted for more than 85% of the total runoff for watersheds of southern Saskatchewan; and runoff volumes that were expected to occur once in 1.4 years from each watershed were about equal.

Evaporation suppression from free water surfaces (21)—Evaporation losses were measured from two dugouts in 1966. The water surface of one dugout was treated with an evaporation-controlling powder, Aqualox NX[9] and the other dugout was untreated. The monomolecular surface treatment reduced evaporation losses by 16.7 to 21.0% during the season.

Snow fences 8 ft high were placed around both dugouts in 1967 to reduce the wind action on the water surface. Evaporation data were obtained as well as daily water-temperature variations in the dugouts at 10 levels ranging from 50 cm above the water surface to the bottom of the dugout.

Grain Harvesting

Combine horsepower requirements—The horsepower required by the cylinder of a combine increased rapidly as the quantity of grain and straw threshed per minute increased. The rasp-bar type of cylinder demanded more power than the spike-tooth cylinder when threshing wheat. Both cylinders used more power when threshing Chinook wheat than when threshing Canthatch. A higher power demand was made when straight combining than when picking up and threshing windrowed grain.

This increase of power requirement with increasing amounts of grain and straw caused a depletion of the available power supplied through the main drive of the combine. The result was a decrease in operating speeds of all components of the combine. Thus, the efficiency of both the threshing and separating mechanisms can be seriously reduced and cause a loss of grain at the rear of the combine.

Grain losses in harvesting—Grain losses before and during a barley-harvesting operation have been recorded. The natural loss, which occurs throughout the development and maturing stages of plant growth, was often the largest loss. It varied from 0.8 bu/acre at the 40% kernel moisture stage to 2.3 bu at the fully ripe stage. The windrowing loss increased as the crop was cut at successively later stages of maturity and reached a maximum of 0.4 bu/acre at a kernel moisture stage of 26%. Losses caused by the pickup decreased as windrowed barley, cut at successively more mature stages, was harvested. The loss from the rear of the combine was 1.25 bu/acre.

Artificial drying—The combining of wheat at a stage of maturity somewhat earlier than the fully ripe stage followed by artificial drying has received some acceptance in Saskatchewan. Preliminary tests of the quality of the end product have shown that 1,000-kernel weight and protein content were not affected by this practice. However, total P in the kernels and germination were seriously suppressed. Further studies, to determine if this damage was caused by heat during the drying process or if the suppression of those qualities was of physiological origin were carried out in 1967.

Windrowing studies (6)—Observations of the way in which windrows of wheat were supported on the stubble, of crops seeded with different machines, were

[9] Obtainable from M. Michel and Co.

made. Crops were seeded with the one-way disc seeder (random spacing), the press drill (6-inch spacing), and the hoe drill (7-inch spacing). The grain was cut with a 12-ft high-angle table, and with a 12-ft low-angle table self-propelled windrower, and with a 15-ft pull-type windrower with a double windrow attachment. The short crop of 1967 provided a minimum stubble height. The center-delivery self-propelled windrowers made a wide, thin windrow that settled badly on all drill spacings and the crop was hard to recover. The 15-ft single windrow did not settle as much as the narrower ones, even on the wider drill spacings. A second windrow, when using the double windrow attachment, was placed directly on top of the first windrow. This combination provided enough bulk so that both windrows were picked up cleanly.

Plot Equipment

Seeders—A four-row cereal cone seeder with side-band fertilizer attachment was developed. The performance was excellent. An 11-row cone seeder for seeding forage crops and placing fertilizer performed satisfactorily when a two-way hydraulic cylinder was added to control the depth. Both seeders used the Allis Chalmers G as a power unit. A four-row cone seeder with accurate depth control was developed, using the International Cub Cadet as a power unit. Unsatisfactory performance was due mainly to the unsuitability of the power unit. Modifications are now under way to overcome the problems experienced. Four-row centrifugal dividers are being manufactured and mounted on two seeders for the Research Station at Lethbridge, Alta.

Modifications to the Swift Current Harvester II (27)—The Swift Current Harvester II was modified and tested in 1966. Two changes were incorporated, neither of which affected the basic frame design. One change provided a quick-emptying, side-hinged sample box and the other provided an alternative axle assembly for increased versatility.

Laboratory Apparatus

Sunflower seed huller—An improved huller constructed of metal was developed for the Research Station at Morden, Man. Variable rotor speed from 200 to 4,000 rpm was achieved by use of a SCR variable voltage controller and a d-c shunt wound motor.

Automatic water dispenser—A device was developed for the Research Station at Regina, Sask., to dispense water into greenhouse pots until the original preset weight was reached, thus restoring soil conditions to the original moisture stress. The operation requires placing the pot on a balance and pushing a button. Water is automatically cut off at the preset weight. The device reduces watering time by one-third.

A laboratory sprayer—A small sprayer was developed to apply insecticides or herbicides in the laboratory. The sprayer boom, mounted on a track, is pulled across the target area by a cable operated from an electric motor. The push-button controls are located at one end of the track. An attachment for low-volume spraying is being developed.

Automatic feeder—A dispenser that automatically releases a quantity of feed at a preset time, controlled by a time clock, was developed to use for night and weekend feeding of test animals.

Instrumentation

Thermocouple switching module—This module enables a single-pen recorder to monitor up to 52 variables and step through the 52 points automatically. The switching period may be adjusted from 1 sec to 1 min.

Lysimeter weighing system—An electronic weighing system was developed to continuously monitor and record the lysimeter weight. Sufficient accuracy has been achieved when the readout instrument is located under the lysimeter. However, when remote readout is employed errors are introduced. Research is continuing to overcome this problem.

Wheat

Breeding—Four new sawfly-resistant wheat lines are being evaluated in national cooperative tests. One of these (C.T. 758) was also grown on a larger scale for quality evaluation.

The F_2 generation of four double-cross populations, which are part of a recombination program involving 16 crosses to improve yield, are being grown in California in 1967–68. Four F_1 populations were used in crosses with the American wheats Chris and Justin, the Mexican wheat Sonora 64, and a Canadian strain C.T. 762 (Rescue × Chinook 2 × Lee[2] × Kenya Farmer).

To study the "crossability" of Chinese Spring wheat with rye, crosses were made between Chinese Spring and several other hexaploid wheats. Parents and F_1 plants were crossed with rye. The reason why Chinese Spring produces seed when pollinated by rye was not apparent in the F_1 hybrids.

Variety tests—None of six Triticale lines equaled Manitou, Conquest, or Harmon when grown on dry land, either at 6-inch or 12-inch spacing. Growing conditions were very dry.

Pitic 62 was the highest yielding (98.3 bu/acre) of 15 wheats grown on irrigated land, the yield being 21 bu higher than that of Manitou. On dry land these two varieties did not differ significantly in yield.

Rye

Breeding—Two selections have been entered in the national cooperative trials. S.C. 66 is a selection from the cross Select II × Antelope, and S.C. 67 is a selection from Petkus × Dakold. These selections display improvements in length of straw, resistance to lodging, and kernel characteristics. Selections are being made within the German spring variety Petkus for earlier maturity and shorter straw.

Alfalfa

Breeding—A diallel crossing program of 18 clones disclosed that specific and general combining ability were involved in seed set and fertility relationships. For any one plant in all crosses the seed set averaged 3.6 seeds per pod with a low of 2.0 seeds. The highest average fertility for any one plant in all crosses was 78% and the lowest 48%. One plant formed no seed on selfing and one formed 2.8 seeds per pod. The highest fertility upon selfing was 68%. A population of 4,000 plants from this crossing program was established in a breeding nursery in 1967.

One hundred vigorous, winter-hardy, creeping-rooted plants selected out of an F_1 population from intercrosses between selections of Russian origin and creeping-rooted Swift Current selections were intercrossed to develop breeding populations. More than half the clones were resistant to bacterial wilt. The clones and polycross progenies were planted in replicated trials in the field for agronomic assessment.

Roamer (8)—Breeder seed of the new variety Roamer (licensed 1966) was increased in 1966 and 1967. Two hundred pounds were released to growers in 1967, and a similar amount of seed will be distributed in 1968.

Seed increases of alfalfa in growth chambers by use of the alfalfa leaf-cutter bee (10)—About 20 female bees, *Megachile rotundata* F., pollinated 30 plants (two of each clone) during a period of 1 month; the plants produced 320 g of seed (650 kg/ha). The 15 clones differed significantly in amount of seed per plant. The lowest yielding clone produced only 2.7 g of seed per plant, the highest 17.8 g. The seed yield of the clones tended to follow a similar order in three consecutive tests ($r = 0.77$, 0.53, and 0.49 between tests).

Rate of germination of alfalfa varieties at four temperatures and relationship to winterhardiness (9)—Alfalfa varieties of diverse genetic origin differed significantly in rate of germination at each of 5, 10, 15, and 20 C. The rates of germination of varieties at the different temperatures were correlated ($r = 0.6$), but there was a significant variety × temperature interaction. There was little relationship between the rate of germination of alfalfa varieties and their winterhardiness. It should be possible to develop rapid- or

slow-germinating strains within any hardiness class.

Grazing alfalfa varieties and observations on bloat (1)—Cattle grazed four alfalfa varieties grown on dry land at Swift Current, Sask., from 1963 to 1965. No severe symptoms of bloat occurred in any year, and there was no evidence that any one variety had a greater tendency to cause bloat than another. The variety Rambler yielded the most forage and provided the most cattle days of grazing per acre, followed by Siberian, Grimm, and Alfa. The stands of Grimm and Alfa were considerably thinner than those of Rambler and Siberian, indicating that their persistence was poorer.

Genetic differences in chemical constituents and morphological characters in alfalfa—Five alfalfa populations totaling 326 clones were grown in the greenhouse and studied in three replicates for variability in leaf-to-stem ratio, leaf size, branch internode, interval between flowering, and content of the following constituents in leaf and stem: N, P, K, Mg, Ca, S, fiber, ether extract, and dry-matter digestibility. Highly significant differences were found for all characters between populations and among plants in populations. The components of variance indicated that chemical constituents may be as highly heritable as morphological characters. Dry-matter digestibility was the least variable of all characters studied.

Russian Wild Ryegrass

Breeding—About 2,100 single plant selections of Russian wild ryegrass, *Elymus junceus* Fisch., were evaluated for seedling vigor in the second cycle of selection. Plant lines showing good emergence from a 2.5-inch depth of seeding in the greenhouse were space planted in the field and are being evaluated for vigor, yield, and various agronomic characters. Further selections were made in 1967 and the plant lines will be put through the third cycle of selection for seedling vigor based on the emergence test.

Inheritance of a dwarf character (18)—Dwarf plants are only about a tenth the size of normal plants. Leaf length of the dwarf plants is one-third and leaf width one-half that of normal plants. Inflorescences seldom form on dwarf plants and those that do form fail to produce seed. The dwarf character is monogenic and recessive, and has tentatively been assigned the gene symbol dw_1.

Effect of age on the germination and emergence of seed harvested by two methods at progressive stages of maturity (14)—After 5 years in storage, seed harvested by the straight-combine method germinated less than 60%, whereas seed harvested by the swather-combine method on the last 3 or 4 days before excessive shattering occurred germinated 75% or higher. Seed harvested at immature stages by either method of harvesting deteriorated in germination. At more mature stages, however, seed harvested by the straight-combine method deteriorated in germination much more than that harvested by the swather method. Deterioration in the ability of the seed to germinate and emerge from a 1-inch depth was closely related to seed size and moisture content of the seed at time of harvest.

Intermediate Wheatgrass

Breeding—The second cycle of selection for seedling vigor in intermediate wheatgrass, *Agropyron intermedium* (Host) Beauv., based on emergence from a 3-inch depth of seeding indicates that the characteristic is highly heritable and it should be possible to make rapid progress by selecting on this basis. The relationship of this characteristic to yield potential is now being determined.

Tall Wheatgrass

Orbit (16)—Orbit, a new variety of tall wheatgrass, *Agropyron elongatum* Host, yielded 590 lb of Breeder seed, which germinated 80%. A considerable quantity of Certified seed will be available in 1968. In tests, Orbit was superior to all other strains in winterhardiness and produced 50% more seed.

Grass Seed Production

Long-term effects of row spacing and fertilizer on the productivity of Russian wild ryegrass (19)—The study was conducted from 1947 to 1966. The optimum row spacing for highest seed production was 3 ft and for highest forage production it was 2 ft. A 250-lb/acre rate of 16-20-0

significantly increased the seed and forage yield over a 135-lb/acre rate, which in turn significantly increased the yield over the unfertilized plots. During the 19-year period seed was produced in only 9 years. The grass failed to head out in very dry years. Width of row increased with age of stand. However, there was still bare ground between rows spaced 4 and 3 ft apart after 19 years. No weed invasion occurred during this period. Increases in precipitation in August and September increased the seed yield the next year to a greater extent than precipitation in any other month. However, precipitation in March, April, and May was most effective in increasing the forage yield.

Grass–legume mixtures for irrigated pastures—Ten simple grass–legume mixtures fertilized at an optimum rate are being grazed by cattle in a four-replicated test. Most of the mixtures contain two grasses with one legume. The grasses being evaluated are Carlton bromegrass, creeping red fescue, Chief intermediate wheatgrass, reed canarygrass, Climax timothy, Troy bluegrass, and Chinook orchardgrass; and the legumes are Rambler alfalfa, Beaver alfalfa, Leo birdsfoot trefoil, and Pilgrim white clover.

After 2 years of measurement, seasonal dry-matter yields have varied from 7,000 to 11,000 lb/acre for lowest and highest mixture to provide 300 to 500 animal days of grazing per acre. To date, mixtures containing Troy bluegrass, bromegrass, or reed canarygrass with alfalfa have yielded the most, while mixtures containing birdsfoot trefoil or white clover have yielded the least.

Annuals, perennials, and rotations—Experimental comparisons are being made between perennial forage crops and cereal grains for hay and grain production when the annual crops are grown in various 2-year and 3-year rotations. The annual crops include wheat, oats, fall rye, sunflowers, and corn, and the perennial crops include alfalfa alone and a crested wheatgrass – alfalfa mixture.

Average annual yield of hay in tons per acre during the 2 years 1966 and 1967 were as follows: grass and alfalfa, 2.6; alfalfa, 2.3; fall rye on fallow, 2.1; corn on fallow, 1.6; oats on fallow, 1.5; wheat on fallow, 1.3; and sunflowers on fallow, 1.2. In 1967, the second-crop or stubble-crop hay yields were as follows: oats after sunflowers, 0.8; oats after fall rye, 0.7; fall rye after oats, 0.6; and sunflowers after oats, 0.4 tons/acre.

Rates of seeding alfalfa in dryland mixtures (12)—Rambler alfalfa was seeded at 0.25, 0.5, 1, 1.5, and 2 lb/acre with a fixed amount of crested wheatgrass and Russian wild ryegrass. Data from 7 years showed that the 1-lb rate of seeding resulted in yields as high as those from mixtures containing more alfalfa. On the other hand, mixtures containing only 0.5 lb of seeded alfalfa yielded 25% less, and those containing only 0.25 lb 40% less than the one containing 1 lb of seeded alfalfa.

Row spacings and dryland yields of alfalfa—Rambler alfalfa in 18-inch spaced rows has outyielded alfalfa grown in narrower or wider spaced rows. Over a 4-year period (1964-67) the crop in 18-inch rows outyielded the crop in 12-inch rows by 10 to 23%, and that in 24-, 30-, and 36-inch rows by 15 to 55%.

SOIL SCIENCE

Soil Moisture and Agrometeorology

Measurement of evapotranspiration—During the summer of 1967 data were collected to evaluate the reliability of several empirical and instrumental methods of estimating evapotranspiration in a semi-arid climate. The basis for comparison will be hourly and daily evapotranspiration measurements as determined by a large weighing lysimeter. Neutron attenuation techniques, energy balance determinations, and soil moisture budgeting methods will be included in the comparison.

Effect of rate of seeding on yield of wheat—Wheat yield was not significantly influenced by seeding rates of 0.33, 0.67, 1, or 1.5 bu/acre on either stubble or fallow land in 1967. The crop on stubble

plots used slightly more moisture than fallow crops at all depths below the 1-ft level but the rate of water use during the season was comparable for all seeding treatments.

Influence of soil moisture on yield components of wheat—Growth-room experiments indicated that the grain yield of wheat was reduced if the plants were grown under low moisture stress. When the moisture stress was varied during different growth stages, maximum grain yields were obtained when plants were grown under "dry" conditions until late shotblade and under "wet" conditions thereafter. Moisture manipulations affected the number of heads per plant and the percentage of seed set, but had little or no effect on the number of florets per head or the mean kernel weight.

Effect of additional water and plant nutrients on wheat yields—A series of experiments with soils placed in tanks 5 ft deep by 15 inches in diameter has been conducted during the past 40 years. In 1965, the treatments were altered to compare the yield of wheat when water and fertilizer (N and P) were added to tanks producing wheat continuously and to tanks producing wheat in a wheat–summerfallow sequence. The results indicate that the nutrient supply in the soil is very nearly in equilibrium with the average moisture supply for continuous wheat production since neither water nor plant nutrients alone consistently increased the yield. On the other hand, the addition of water and plant nutrients together more than doubled the average yield during the past 3 years (from 24.6 to 63.5 bu/acre).

In the summerfallow–wheat cropping sequence additional water had a greater effect on yield than additional plant nutrients. Plant nutrients alone increased the yield by 1.6 bu/acre. Additional water increased the yield by 19.2 bu/acre and additions of both water and plant nutrients increased the yield by 39.3 bu to an average yield of 74.8 bu. Additions of water without additional plant nutrients had a much greater effect on the crop grown on summerfallow than on the continuous wheat crop. This attests to the importance of nitrogen mineralized during the summerfallow year and to the fact that even during comparatively wet years such as 1966 the lack of available moisture seriously restricts wheat yields in southwestern Saskatchewan.

Soil Erosion

Plant residues and erosion of soil by wind (3)—The relationship between sand flow in a wind tunnel and the quantity of wheat stubble on the surface of the sand tended to be sigmoidal. There was an initial phase when small amounts of stubble had little effect on sand flow, followed by a very rapid decrease in flow when additional increments of stubble were added to the surface. Sand flow approached zero at stubble rates ranging from 1,200 kg/ha for a wind velocity of 5.36 m/sec to 7,200 kg/ha for a wind velocity of 8.49 m/sec. At a wind velocity of 10.28 m/sec the addition of 1,800 kg/ha of wheat stubble tended to increase sand flow.

An automatic single-screen soil sieve (4)—An automatic single-screen rotary soil sieve was designed and constructed to help overcome some of the limitations of the hand-operated rotary sieve. It consists of a screen-covered auger 22.86 cm outside diameter and 91.44 cm long mounted on a light frame and operated by an electric motor. It is covered by a 22-gauge brass screen with 0.84-mm openings. The frame is adjustable to change the slope, and the direction of turning is reversible so that the sample may be passed back and forth through the sieve if desired.

Seasonal and yearly changes in aggregate distribution in soils—Repeated sampling over a 10-year period has indicated that the percentage of the soil in aggregates less than 0.84 mm in diameter (erodible fraction) varies with time depending both on the month of the year and on the year. The erodible fraction in the soil was much higher during the period 1958 to 1961 than it has been during recent years. The soil also appears to be much more erosive during the month of May than at any other time during the year.

Effect of freezing and thawing on soil structure (11)—The percentage of aggregates less than 1 mm in diameter in a clay soil may be increased, decreased, or

unaffected by freezing and thawing, depending on the initial moisture content, the initial size of soil aggregates, and the method of drying the sample.

If the initial moisture content was equivalent to 15 atm, little or no change in the size of soil aggregates could be detected after freezing and thawing. However, at a moisture content equivalent to 0.1 atm, freezing and thawing followed by air drying tended to disintegrate coarse particles and cause aggregation of finer particles. If the sample was dried while frozen, the percentage of aggregates less than 1 mm increased dramatically.

Effect of snow cover on the erodibility of soil—Snow fences were used to maintain a deep snow cover on summerfallowed clay loam soil during the winter of 1966–67. Monthly sampling indicated that the percentage of soil in the erodible fraction (aggregates less than 0.84 mm in diameter) decreased continuously during the winter. In November 50% of the soil was in the erodible fraction and by March, 17%. On the other hand, when vented shelters were used to keep snow off the soil, the percentage of soil in the erodible fraction remained constant throughout the winter.

Soil Fertility and Crop Management

Seedbed preparation for winter wheat—In 1966 and 1967 the average yield of winter wheat was greater (33 bu/acre) when seeded on "chemical fallow" than on conventional summerfallow (21 bu/acre).

In "chemical fallow" no tillage implements were used from harvest of the preceding crop until seeding of the winter wheat, about a year later. Weeds were controlled by chemicals and the crop was seeded with a hoe press drill. The protection afforded by the snow trapped by the stubble during the winter was probably the reason for increased yields on the "chemical fallow."

Fertilizer trials with cereals—In 1967, the program to establish the relationship between the returns from various rates of N and P applied to wheat and methods of estimating available N and P in the soil was continued. Fertilizer tests were conducted on adjacent summerfallow and stubble fields at 14 locations in southwestern Saskatchewan. In general, returns from the use of fertilizer were below normal because of adverse weather.

Profitable returns were obtained from applications of P only at locations where $NaHCO_3$-extractable P was less than 10 ppm (9 of the 14 locations). Maximum net returns were obtained from an application rate of 15 to 20 lb of P_2O_5 per acre. Results from previous years indicate that profitable returns can be expected from soils that contain less than 15 ppm $NaHCO_3$-extractable P. Consequently, it appears that the level of available soil P above which fertilizer applications are not profitable depends on the weather during the year.

The average nitrate-nitrogen content of the soil at seeding was 69 lb/acre 2-ft on sites that had been summerfallowed the previous year. The application of 10 lb/acre of N in addition to the most profitable rate of P was profitable at 2 of the 14 locations. On sites that had been in crop the previous year, the average nitrate-nitrogen content of the soil at seeding was 36 lb/acre 2-ft. This varied from 23 to 115 lb among locations. The application of 10 lb of N in addition to the most profitable rate of P was profitable at 5 of the 14 sites. The application of an additional 15 lb of N (total fertilizer application = 30 lb N and 20 lb P_2O_5 per acre) was profitable on one site only. This is in contrast to results obtained in 1966 when profitable returns were obtained from N applications of up to 60 lb/acre at all locations where the initial soil nitrate-nitrogen content was less than 60 lb/acre 2-ft.

Fertilizer on native range—A single application of 16-20-0 at 25 lb/acre or higher influenced yield of native range for 5 to 6 years after the year of application. Because of the low average annual production of native range, 2 or 3 years are normally required to recover the investment in the fertilizer. Soil analyses indicated a consistent increase in the $NaHCO_3$-extractable P in the 0- to 6-inch soil layer on all plots where P had been applied up to 6 years previously. Increases were detectable from application of as

low as 5 lb of P_2O_5 per acre. There was no measurable increase in nitrate-nitrogen in the soil even in the second year after application from rates of as high as 100 lb of N per acre, applied as NH_4NO_3.

Mineralization of soil nitrogen—Measurements of soil nitrate fluxes and N absorption by a developing crop of wheat indicate that the crop is highly dependent on the initial nitrate in the soil during the early stages of development. Mineralization does not appear to become an important source of plant N until about mid-July, when the crop is normally at shot-blade stage and tillering is completed. Consequently, when the mineral N content of the soil is below optimum at seeding, application of fertilizer N is required to obtain normal crop development.

Changes in available soil phosphorus levels—Repeated sampling of the same fields since 1962 indicated that the level of available P (A-value determinations) in the soil tends to remain relatively constant with time when no manure or fertilizer is applied. However, there was some indication that higher values might be obtained in May than in any other summer month.

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A. J. Tosh	Officer in Charge

Experimental Farm, Mile 1019, Alaska Hwy., Y.T.

R. M. Tait	Officer in Charge

Departures

D. W. Smith, B.Sc., M.Sc., Ph.D. Resigned August 1967	Fruit and vegetable management (Beaverlodge)
V. G. Peterson, B.S.A. Resigned December 1967	Forage management (Prince George)

INTRODUCTION

The Research Station at Beaverlodge is concerned with problems basic to the stable production of cool-season crops in northwestern Canada. The Station is assisted in this research by associated Experimental Farms at Prince George, B.C., Fort Vermilion, Alta., Mile 1019, Alaska Hwy., Y.T., and Fort Simpson, N.W.T.

Because of the recent reorganization, much of the activity is still concerned with program modification. Progress in long-term research and the results of completed research are reported. None of the research is described in detail and, unless significant to the application of the results, location of the research is not specified. Detailed scientific accounts of completed research are listed in the publications section. Reprints of these can be obtained from the Station.

A. A. Guitard
Director

CLIMATE

Crop–Climate Relationships

The effects of latitude on temperature, precipitation, and daylength, and the relationship of these to crop production have received special study. Data collection has been standardized at all locations. Detailed reports of climatic relationships will be published at 5-year intervals.

SOILS

Nitrogen

Requirements for spring cereals—Lack of N is one of the main deterrents to high yields of spring cereals on Gray Wooded soils. In 17 field tests on 12 soils during the past 3 years the average yield of oats and barley was 12 cwt/acre after application of optimum quantities of PKS ferti-

lizer. A further addition of 40 to 80 lb of N/acre increased the average yield to 28 cwt/acre.

Requirements for fall rye—Fall rye also requires N for maximum yields. An application of 30 lb/acre was generally sufficient, but on some soils, as much as 60 lb/acre was beneficial. Best yields were obtained when as much as 7 lb/acre was applied with the seed and the remainder applied as a topdressing in the fall. There was no advantage in applying all or part of the N as a spring topdressing during the 2 years the test was conducted.

Form of nitrogen—For barley on stubble at Beaverlodge, NH_4NO_3, $(NH_4)_2SO_4$, and urea were equally effective when applied with the seed at rates of 20 and 40 lb of N/acre applied with 9 lb/acre of P.

Nitrogen placement—Flax and rapeseed yields were reduced when even moderate quantities of N were applied with the seed. There were reductions in the yield of flax with applications of more than 5 lb/acre and of rapeseed with more than 10 lb/acre. There was no reduction in the yield of wheat when as much as 60 lb of N/acre was applied with the seed.

Sulfur

Requirements for spring cereals (8)—Yields of cereal grains were depressed by lack of S in some soils. Since the soils deficient in S were also deficient in N, yield responses to the application of S were only obtained after the N requirements had been met. Plot yields were often doubled by the addition of S.

Requirements for rapeseed—Rapeseed grown on two S-deficient Gray Wooded soils yielded 2 cwt/acre or less after soils had been fertilized with NPK and 12 cwt/acre after being fertilized with NPKS. Yield increases were as large after application of 10 lb of S/acre as they were after application of 20 or 40 lb/acre.

Factors Influencing Nutrient Availability

Organic matter—Past studies that demonstrated high yield increases of cereals after growth of perennial forage crops or after application of barnyard manure were expanded to cover a wider range of soils and latitude. Tests extend from Vanderhoof, B.C. (lat 54° N), to Fort Simpson, N.W.T. (lat 62° N). The soils range from coarse to fine textured and from Black to Gray Wooded. The object of present studies is to determine the mode of action of organic matter in improving Gray Wooded soils both chemically and physically.

CROPS

Cereals and Oilseeds

Barley—The breeding program to combine early maturity and high yield continued, with emphasis being placed on components of yield. The BC_3 generation in a backcrossing program designed to transfer into Conquest the daylength nonsensivity and earliness of Olli yielded 10% more than either parent and was intermediate between the two in maturity.

Flax—Indications that flax is less affected than barley, rape, or wheat by the medium to extreme acidity of some of the northern soils has increased interest in this crop. A number of native annual and perennial *Linum* species, collected in the Northwest Territories, are being evaluated for use in the breeding program.

Grasses

Creeping red fescue (3, 15)—The new variety Boreal, licensed in 1966, is being well received by growers. The breeding program was continued with the selection of types most suited to production of turf and pasture. Turf selections are being screened for resistance to red thread disease, *Corticium fuciforme* (Berk.) Wakef., at the Research Station, Saanichton, B.C.

Reed canarygrass—To expedite the breeding program, a new generation was produced in a controlled environment in 6 months. Since reed canarygrass requires both low temperature and short photoperiod for induction, seedlings were grown at 70 F in the greenhouse for 40 days and then subjected to a temperature of 55 F,

and a photoperiod of 10 hr, for 70 days in the growth chamber. After induction plants were returned to the greenhouse and held at 70 F under continuous illumination until seed maturity. By this method it was possible to harvest field-grown polycross Syn_1 seed in 1966 and to establish preliminary field tests of three new synthetics with Syn_2 seed in the spring of 1967.

Induction and initiation (14)—The phasic development of 18 grass species was studied by periodic year-round transfer of the plants from the field to greenhouses and growth chambers. Microscopic examinations of stem apices were made with each transfer to determine the stage of floral development. Tillers of most grasses appear to undergo floral induction in the fall and floral initiation in the spring at Beaverlodge. However, there are exceptions. Tillers of Russian wild ryegrass appear to require one winter to stimulate floral induction and a second for floral initiation.

Foreign varieties of grasses for seed production—Research on foreign varieties of grasses was expanded with the establishment of over 200 entries in nonreplicated nurseries. Foreign varieties of timothy, particularly those from northern Europe, showed considerable promise as seed specialties, and further evaluation of 40 varieties in replicated tests was started.

Northern native species—Twelve hundred ecotypes, mainly grasses, belonging to 75 species and 25 genera, were collected from British Columbia, Alberta, and the Yukon and Northwest Territories and planted in an introduction garden at Beaverlodge. The purpose is to classify and evaluate for forage potential the native plants persisting in northern environments. Systematic collection will continue.

Establishment of native species—For seeding newly cleared land at Fort Vermilion, breaking with a moldboard plow or a heavy serrated disc plow was necessary before smooth bromegrass, crested wheatgrass, and creeping red fescue could be established. Incorporation into the native sod remaining after removal of the trees was all that was needed for good establishment of native *Calamogrostis* and *Agropyron* spp.

Tolerance to herbicides—Diallate, triallate, and barban were applied to a number of forage species seeded without a nurse crop. A light seeding of cultivated oats was used as a check for time of application of barban. The forages were well established by mid-August, when plant counts indicated that triallate slightly reduced stands of timothy and Russian wild ryegrass, moderately reduced creeping red fescue, crested wheatgrass, reed canarygrass, and alfalfa stands, but seriously reduced stands of bromegrass. Barban caused little reduction in stands of bromegrass, moderate reduction in the stand of Russian wild ryegrass, and reduced stands of the other species by one-third to one-half. Diallate moderately reduced stands of Russian wild ryegrass, but severely reduced stands of all other species.

Legumes

Alsike clover (4)—The program designed to develop varieties of alsike clover with an upright growth habit, hardiness, and high forage yield, was continued. Sixteen parents with these characteristics were crossed in a diallel program in the greenhouse during the winter. The progeny were space planted in the field in 1967.

Alfalfa—Previous research showed that as tripping of a standardless mutant by honeybees was not sufficiently more frequent than tripping of normal alfalfa flowers this mutant had no practical value in seed production. Further work indicated that the leaf-cutter bee, *Megachile rotundata* (Fabr.), also prefers normal alfalfa flowers. Like the honeybee, the leaf cutter was disoriented by the mutant floret and attempted to trip the florets by sticking its head between the wing and keel petals. Yields of seed from the best mutant selections were much less than those of normal plants.

Vegetables

Production on permafrost—Twelve years of testing in a garden at Inuvik, N.W.T. (lat 68°N) showed that a wide range of vegetables can be grown in the open over permafrost. Under natural vegetation only the top 15 inches of soil thaws out, but 8 years after clearing and cultivating the soil

thawed to a maximum of 85 inches. The frost-free period in the garden averaged approximately 50 days, killing frost-free period 70 days, and growing season 90 days. The average July temperature was 57 F, and there were 900 degree-days above 42 F.

Direct seeding produced satisfactory crops of selected varieties of leaf lettuce, turnip, swiss chard, and beet. Seeding inside, pricking into plant bands or peat pots, and transplanting to the field produced marketable crops of cabbage, broccoli, cauliflower, and kale. The soil temperature had to be increased to produce peas, Brussels sprouts, potatoes, and carrots. Clear polyethylene mulches did this most effectively. After polyethylene was placed on a smooth seedbed, temperatures were increased by as much as 10 F at 2 inches below the surface. When placed over a 14-inch-high ridge of soil, the temperature increased by as much as 16 F at 2 inches.

Fruit

Winterhardiness in raspberry (12)—In red raspberry an association between late summer growth and early frost injury was found. The varieties Madawaska, Viking, and Comet grow more quickly and are more susceptible to early frost injury than the slower growing varieties such as Trent, Chief, and Honeyking.

Ornamentals

Native ornamentals—A species of beardtongue, *Penstemon fruticosus* (Pursh) Greene ssp. *scouleri* (Lindl.) Penn & Keck, which is native to British Columbia, thrives well under cultivation in north-central British Columbia. Methods of propagating this low-growing, herbaceous perennial are being investigated.

Flowers on permafrost—A number of flowers were grown on permafrost at Inuvik, N.W.T., in association with the vegetable trials. The most suitable ones were selected varieties of *Lobularia, Eschscholtzia,* and *Gypsophila* from direct seedings, and *Calendula, Dianthus, Dimorphotheca, Tagetes, Matthiola bicornis,* and *Petunia* from transplants.

WEEDS

Scentless Mayweed

Control with picloram plus 2,4-D—Picloram has previously been the most effective chemical for the control of scentless mayweed, *Matricaria maritima* L. var. *agrestis* (Knaf) Wilmott. In a crop of fall rye, nearly complete control was again obtained with 4 oz of active ingredient of picloram per acre, but equally good control was obtained with an application of 8 oz of a 1:16 mixture of picloram and 2,4-D per acre. Scentless mayweed has a high tolerance to 2,4-D, but apparently the two herbicides have a synergistic relationship that is stronger at the 1:16 ratio than when the proportion of picloram is higher. Four oz of active ingredient of picloram per acre permanently injured the rye, but there was no injury from the 1:16 picloram and 2,4-D mixture.

Couchgrass

Control with trichloroacetic acid combined with tillage—Best control of couchgrass was obtained by cultivating to break up the rhizomes, applying trichloroacetic acid at 20 lb of active ingredient per acre when the new rhizome buds were about 1/8 inch long, and afterwards thoroughly tilling at approximately monthly intervals until freeze-up. The best implement for the first cultivation was the rotovator, but a one-way disc used on the halflap was also satisfactory. The rotovator, one-way disc, and heavy duty disc harrow were suitable for subsequent cultivation. The trichloroacetic acid was best applied with an underground sprayer, but application with a conventional sprayer, followed immediately by incorporation of the herbicide, was also satisfactory. The application of N fertilizer did not greatly increase the kill of couchgrass. The weakness of the method is that the soil must remain moist from the time it is first tilled until the trichloroacetic acid is applied.

Management of Honeybees

Overwintering in southern British Columbia—For each colony taken from Beaverlodge and wintered in the Fraser Valley, five 2-lb packages as well as the original colony were returned in the spring. This amount compared well with a return of 4.4 packages during 1965–66 and 5.9 during 1964–65. Small colonies made up in August with 2 lb of bees and a queen were also successfully wintered in single-brood chambers and returned with 3 lb of bees.

Effect of dates of hiving on egg laying (10)—Colonies hived from April 4 to 19 averaged 300 and 700 eggs per day in the first and second brood cycles respectively, whereas colonies hived in late April and early May averaged 700 and 1,100 eggs per day during these cycles. Consequently, at the commencement of the main honey flow in July, early hived colonies were very little stronger than those hived later.

Disease Control

Irradiation of brood frames for control of European foulbrood—A preliminary test in cooperation with the Apiculture Section of the Entomology Research Institute, indicated that irradiation of brood frames infected with European foulbrood did not control the disease. Despite irradiation as high as 200,000 rads per frame, colonies installed on irradiated equipment became diseased, although the incidence of the disease was lower in colonies containing frames irradiated at the higher dosages.

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Research Station
Lacombe, Alberta

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L. J. Piening, B.Sc., M.Sc., Ph.D.	Plant pathology

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D. R. Walker, B.Sc., M.Sc.	Soil chemistry

Solonetzic Soil Substation, Vegreville

R. R. Cairns, B.S.A., M.Sc., Ph.D.	Officer in Charge Soil physics and chemistry

[1] Appointed June 5, 1967.

INTRODUCTION

This report summarizes the main research findings for 1967 at the Research Station, Lacombe, and the Solonetzic Soil Substation, Vegreville, Alberta. Details of a number of projects have been published and reprints are available.

The analyses of the data from the study of hog carcasses across Canada showed the efficiency of the computer and the close cooperation among various segments of the swine industry. The huge task involving 5,000 carcasses and 149 variables on each was completed in a fraction of the time it would have taken a few years ago.

The studies on seed size and source produced interesting and valuable results. We have not been able to determine the reason or reasons for the real differences due to source, but it is apparent that both seed size and source must be considered in testing and breeding programs.

The crop and weed transpiration studies indicated that the new quick-killing but selective herbicides may contribute to moisture conservation. Another new herbicide, picloram, controls Canada thistle, but its residue affects subsequent crops, particularly wheat.

The reports from the Vegreville substation that high osmotic pressure of the soil solution from Solonetzic soils restricts plant growth may be important in the management of these soils. Certain early results of deep plowing these soils have been spectacular but variable.

J. G. Stothart
Director

ANIMAL SCIENCE

Beef Cattle

Calving problems with Charolais × Shorthorn crosses—Two-year-old Shorthorn heifers bred to Charolais bulls had extreme calving difficulty. Of 15 pregnant females, four required surgical delivery and six required considerable assistance at calving. The crossbred calves averaged 15 lb heavier at birth than straightbred Shorthorns produced by heifers of the same age (78 vs. 63 lb). Seventeen mature Shorthorn cows, 4 to 12 years old, mated with Charolais bulls had little calving difficulty. Their calves weighed 7 lb more at birth than contemporary straightbred Shorthorn calves.

Swine

Performance of SPF (specific pathogen free) pigs—Sixty pigs from 30 litters representing seven SPF herds reared in isolation in a new piggery gained approximately 0.1 lb more per day, exhibited fewer health problems, and produced fatter carcasses than a similar number of littermates reared with non-SPF pigs in an old piggery. However, the differences among herds and among litters within herds were large and, in some cases, pigs reared in isolation had poorer growth than their littermates reared with non-SPF pigs. In a subsequent test, 53 non-SPF litters were raised at the two locations. The performance of those fed in the new piggery excelled that of the litters fed in the old piggery by the same margin as was noted with the SPF pigs.

Factors influencing rate of genetic improvement with swine—A theoretical study established that selection based on the backfat probe permitted more rapid genetic improvement for percentage yield of trimmed lean cuts than does selection based on complete carcass evaluation of four slaughtered sibs. Also, selection for improved growth rate was most effective when the animals retained for breeding were chosen for their own weight for age.

In a companion study, the rate of genetic progress in closed herd breeding operations was largely dependent upon herd size and generation interval. A herd size of at least 6 boars and 60 sows was required for a reasonable rate of progress. The most rapid progress was realized by replacing all boars annually with sons

that ranked highest for their own performance.

Carcass Studies

Grading the lean content of beef carcasses—Detailed measurements were taken on the carcasses of 78 Shorthorn yearling bulls to establish methods for estimating the proportions of lean, fat, and bone in the round, sirloin butt, short loin, rib, and chuck. These cuts comprised approximately 80% of the carcass weight. The conformation of each bull was appraised before slaughter by a panel of 15 experienced judges.

Commercial grades for the carcasses were 51 choice, 22 good, and 5 standard. The choice carcasses averaged 52.4% deboned-defatted lean, 16.8% bone, and 19.8% fat. The averages for the good carcasses were 53.0, 17.5, and 19.3% and the standards 55.8, 17.7, and 15.2%. The figures for fat included the kidney fat. The correlation between the live animal score and percentage yield of lean was very low.

Measurement of total chemical fat in pig carcasses—In the same group of 36 pigs, correlations between external fat measurements and total fat in the carcass and cuts were significant but low. In general, these relationships were much higher in barrows than in gilts. The correlations between external fat measurements and the fat in the trimmed carcass, the internal fat in the loin, and the kidney fat were not significant.

In the sample of pigs under study, backfat measurements on the live animal and on the carcass were useful in predicting the chemical fat in the backfat trim, but, because of the magnitude of the correlations, were of limited value as indicators of total chemical fat in the carcass and cuts and of little use in predicting internal fat.

Carcass merit in relation to thickness of backfat—The relationship between total backfat thickness (shoulder plus loin fat) and yield of commercially trimmed bone-in lean cuts (ham, loin, picnic, and butt) of the carcass expressed as a percentage of warm carcass weight was studied in a sample of 5,000 pigs obtained in packing plants located in five regions across Canada. The regression equation expressing the relationship between percentage yield (Y) and total backfat (X) was $Y=63.0-3.7X$. Thus for each 0.2-inch increase in total backfat, percentage yield decreased by 0.74%. Carcass weight had very little influence on yield.

This fat–yield relationship was linear across all weight categories and there were no differences between regions in the fat–yield or the weight–yield relationships. These relationships with percentage yield for the bone-in and the boneless trimmed cuts were identical.

Belly yield, expressed as a percentage of warm carcass weight, increased and quality of belly decreased with increasing weight and fatness of the carcass.

The regression equation for predicting total trimmed yield of the carcass with belly included as a constant of 13.5% was $Y = 76.5-3.7X$.

This research was conducted in cooperation with the Canadian Swine Council, the Meat Packers Council of Canada, the Livestock Division of the Production and Marketing Branch, and the Statistical Research Service, Research Branch, Canada Department of Agriculture.

Influence of sex on the quality of cooked pork—Hams were sampled from 144 pigs, 36 each of barrows, gilts, boars, and ridglings, which ranged from 190 to 205 lb liveweight at the time of slaughter. Ham steaks, prepared and cooked by a standardized procedure, were evaluated for cooking aroma, tenderness, juiciness, texture, flavor, and overall preference by a taste panel of six judges. For tenderness and texture, the samples from boars ranked highest followed by gilts, barrows, and ridglings. All sex differences were statistically significant ($P \leqslant 0.05$) for these two characteristics. Ranking for overall score and overall preference by judges was in this same order.

Samples from barrows and ridglings scored higher for cooking aroma than the samples from boars and gilts ($P \leqslant 0.05$), although only three boars and one gilt were unanimously judged objectionable. However, aroma was lowly correlated with flavor ($r = 0.28$), and samples scoring low for aroma were often quite satisfactory for flavor. Samples from boars, gilts, and barrows received scores for

flavor that were close and exceeded the score for ridglings by 0.35 units ($P \leq 0.05$).

Factors influencing commercial grade of pigs in Canada—In a random sample of 32,735 pigs marketed at six locations across Canada, 45% graded A, 46% B, and 9% C. The average weight of the carcasses was 155 lb for both sexes and total backfat (shoulder plus loin) averaged 3.34 ± 0.48 inches for the barrows and 3.06 ± 0.47 inches for the gilts.

Within each of the two main weight ranges specified by grading regulations, the increasing fatness of carcass associated with increasing carcass weight resulted in a downward trend in percentage of grade A carcasses. But the most important relationship between weight and grade was at the break between the two weight ranges. Thus carcasses weighing 150 lb averaged 34% grade A, whereas those weighing 151 lb averaged 60% grade A. Only 1.85% of all carcasses were downgraded for reasons other than fatness. There was no evidence that real differences in carcass merit existed in various regions of Canada.

This study was made possible through the cooperation of the Livestock Division, Production and Marketing Branch, and the Data Processing Service, Financial and Administration Branch, Canada Department of Agriculture.

PLANT BREEDING AND PATHOLOGY

Cereal Crops

Seed source important in testing—Significant yield differences with a source–location interaction were obtained when two separate seed stocks of Conquest barley were tested at several locations in the prairies of Canada and USA. Crops grown from seed produced at Lacombe outyielded seed produced at Brandon, Man., at seven locations with differences ranging from 1.7 to 14.2%. At eight other locations the seed produced at Brandon outyielded the Lacombe with differences ranging from 2.8 to 11.9%. Genotypically both lots of seed were the same. Brandon seed had smaller kernels and the Lacombe seed higher N content. No direct relationships between physical or chemical properties of the seed and yield could be determined. The results show the importance of controlling this nongenetic source of variability in cereal variety testing.

Varietal response to rate and date of seeding—Experiments conducted during the past 2 years have shown a differential response by Olli and Conquest barley to date of seeding but no differential response to rate of seeding. Three rates, 0.75, 1.25, and 1.75 bu/acre, and three dates of seeding, at approximately 2-week intervals, were used. With both varieties seeding at 1.25 bu/acre gave the highest yields. These results agree with previous findings. Olli showed a marked decrease in yield from the second and third seeding dates, from 48.2 to 44.3 to 38.4 cwt/acre. Conquest maintained its yield with averages of 49.9, 51.0, and 51.5 cwt/acre from the three dates. Since Conquest only required 5 to 8 days longer to mature than Olli, it can be used where delayed seeding is desirable.

Coleoptile length and emergence in varieties of wheat, oats, and barley—Results from tests on four barley varieties showed significant differences in coleoptile length. The two varieties having the shortest coleoptile also had the lowest emergence from a seeding depth of 7.5 cm. The differences in emergence were most marked in a soil low in humus. The results indicated that coleoptile length should be considered in barley breeding programs.

Only minor differences in coleoptile length occurred between varieties of oats and wheat and, as they did not influence emergence from 7.5 cm deep, they were not considered of practical importance.

Net blotch in barley—A series of experiments established that when net blotch infection occurs early in the life of the barley plant its effect is much more harmful than would be predicted from the reduction of photosynthetic leaf areas.

Effect of fertility on susceptibility of Gateway barley to net blotch—Significant

differences in the incidence of net blotch were recorded on three Alberta soils. One soil, low in N, produced considerably more diseased plants than two other soils where the N content was higher. Other fertility trials suggested that elements other than N can also influence the incidence of disease and subsequent damage caused by the disease.

Root rot in barley—Observations indicated heavier infection with common root rot in barley grown on summerfallow than in barley grown on barley stubble. Recommended fertilizer applications in all cases reduced the amount of root rot, but the same differential remained.

Forage Crops

Grass–legume pasture mixtures—Pasture mixtures of grasses with Rambler alfalfa were more productive than mixtures with Leo birdsfoot trefoil on the Black soils. Six grasses with Rambler averaged 1.69 tons of dry matter/acre whereas the same grasses with birdsfoot trefoil averaged 1.55 tons. Bromegrass produced the highest yield in mixtures with alfalfa (2.28 tons) and intermediate wheatgrass was most productive in mixtures with birdsfoot trefoil (2.26 tons).

Birdsfoot trefoil appeared to be well adapted to Gray Wooded soils; alfalfa did not thrive on many of these soils. The average yield of grass–trefoil mixtures was 2.14 tons of dry matter/acre, twice the yield of grass–alfalfa mixtures, 1.06 tons.

Sainfoin, another nonbloating legume, did not compare favorably with alfalfa in a 2-year study at Lacombe. It lacked the necessary winterhardiness and yielded only 1.05 tons/acre compared with 1.61 tons for Beaver alfalfa.

Northern vs. southern bromegrass varieties—Redpatch and Saratoga, two new varieties of the southern type, compared favorably with the northern types Carlton and northern commercial in hay production. Results of seed tests conducted in 1966–67 indicated that seed production with Redpatch and Saratoga would not be profitable in central Alberta because they averaged only 35.8% the yield of Carlton.

Oilseed crops—The cooperative trials of oilseed crops included varieties and strains of Polish and Argentine-type rapeseed and brown, oriental, and yellow mustards. Yields in lb/acre were: brown mustard 1,921, oriental mustard 2,364, yellow mustard 1,891, Echo rapeseed 2,031, and Target, a variety of Argentine-type rapeseed that often does not mature before frost at Lacombe, 2,411.

Northern anthracnose of red clover—Successful artificial inoculation with *Kabatiella caulivora* (Kirchn.) Karak. required an extremely concentrated inoculum, above 4 million spores/ml. Cultures from a variety of media indicated that best growth was not necessarily related to the highest viability. A very acid medium (pH 4) and cool temperatures favored viability, as did younger cultures. Older cultures (9 days) showed a reduction in viability. These features may explain some of the difficulties encountered in obtaining consistent infection of red clover plants under artificial conditions.

Horticultural Crops

Emulsified asphalt as a mulching material—Emulsified asphalt was tested as a mulching material on 8 seeded and 13 transplanted vegetable crops. It was applied at two rates, 0.15 and 0.30 gal/yd^2, in bands to correspond to the widths of polyethylene, 18 and 36 inches, that were used in comparison. Emergence of large- or small-seeded crops was in no way deterred by either rate of asphalt application. However, this material did not increase yields or advance maturity in any of the tests. The overnight heat loss and the soil temperatures 2 inches below the surface under the asphalt were the same as in the check (no mulch). By comparison, polyethylene mulches, particularly the clear mulch, advanced maturity and yield of cucumbers and peppers. In previous years polyethylene mulches advanced muskmelon, watermelon, egg plant, sweet corn, and Brussels sprouts.

Weed Control

The effect of bromoxynil and dicamba on transpiration of Tartary buckwheat and barley—Tartary buckwheat, *Fagopyrum tataricum* (L.) Gaertn., sprayed with a quick- and a slow-acting herbicide continued to transpire water until the plants were dead. The quick-acting contact herbicide bromoxynil reduced transpiration by 50% within 1 day and by over 80% within 2 days after spraying. The systemic herbicide dicamba did not reduce transpiration to near this level until 10 days after spraying. These transpiration differences due to the differential herbicide activity were highly significant and influenced the growth of barley when it was grown with the weed and sprayed.

Persistence of picloram in soil—After different intervals up to 3 years, the persistence of picloram in soil was measured with a bioassay technique using sunflowers as the indicator plant. Rates of application ranged from 0.5 to 48 oz/acre on two soil types at Scott, Sask., and two at Lacombe. After 1 year, recovery ranged from 20 to 30% of the original application in soil 0 to 9 inches deep. Recovery of the herbicide applied at 8 oz/acre or higher in the fall declined to about 10% after 24 months and to 6% or less after 35 months for even the highest rates. Two and a half months after spraying in the spring, bioassays at one site showed that over 50% of the picloram activity still remained. Picloram activity was generally concentrated in the surface 6 inches, which indicated limited downward movement due to water in each of the soils.

Rates as low as 4 oz/acre seriously affected the yield of wheat the year after treatment. Barley and oats were not significantly affected at this rate, but they were at higher rates.

Varieties of Canada thistle, Cirsium arvense *(L.) Scop.—Horridum* has serrated, ruffled leaves with an abundance of spines and is the most prevalent variety of Canada thistle. However, variations in ruffling and spininess range to plants with nearly entire leaves and very few or no spines at all. Some of these fit the descriptions of the varieties *integrifolium* and *mite.*

In a study of root systems, 8-inch root cuttings of a smooth-leaf variety *integrifolium* produced nearly twice as many new green shoots as the *horridum* variety in 12 months. Both varieties were able to project shoots through 36 inches of soil placed on the surface of established patches.

The smooth-leaved variety recovered from a low dosage of picloram, 8 oz/acre, after one full season, whereas the common spiny variety recovered less than 5% in the same period. Recovery from treatment with high rates of dicamba and 2,4-D followed a similar pattern, but the differences between varieties was less striking.

Soils

Rotation effect on soil aggregation and organic carbon—A 6-year study showed a small but consistent increase in soil aggregation under sod crops in a rotation, but this regressed to the same level as in a grain, grain, fallow rotation within 1 year after breaking. Organic carbon ranged from 5.5 to 6.0%, but did not change or differ between rotations. The grain, grain, fallow rotation and the 6-year rotation having 3 years in sod crops were originally laid down in 1911.

Minimum tillage requirements for summerfallow in Western Canada—Experiments at seven locations in Western Canada, including Lacombe, indicated that three or four tillage operations were usually enough for satisfactory weed control on summerfallow, and they generally provided highest yields of grain. Two tillage operations were not enough. Nitrate N accumulation at the end of the summerfallow period was greater when weeds were adequately controlled by tillage. Different amounts of tillage had little effect on soil-moisture conservation. The use of herbicides without tillage resulted in inadequate weed control in most years, and slightly less moisture was stored.

Response of barley varieties to N and P fertilization—Significant differences in

their response to fertilizer was found with four varieties of barley on Gray Wooded soil west of Lacombe. Husky gave the greatest response to N and P, Parkland the least, and Gateway and Betzes intermediate. Next year other varieties will be tested on Black soil as well as the Gray Wooded.

Measurement of soil sulfates—Except at very low levels, close agreement was obtained when sulfates extracted from soils with H_2O were measured by a Ba^{133} procedure and a procedure involving reduction of sulfate to H_2S with formation of methylene blue. At very low levels of soil sulfate the reduction to H_2S gave slightly higher readings than the Ba^{133} procedure.

SOLONETZIC SOIL SUBSTATION, VEGREVILLE

Solonetzic Soils

Equilibrium solutions of Solonetzic and associated Chernozemic soils—Cation ratios for Solonetzic soil (Duagh Si. L.) vary more with changes in soil moisture levels within the field moisture range than for geographically associated Eluviated Black Chernozemic soil (Malmo Si. L.). The values of $p\ Na^+ - \frac{1}{2}p\ (Ca^{++} + Mg^{++})$, where p is the negative logarithm of the ion activities, were nearly constant over the entire moisture range in the Malmo Ap and Bt_n horizons. For Duagh soils the comparable concentration ratios were much smaller and decreased with decreased soil moisture. The ionic strength of the equilibrium solutions ranged from 31 to 1,519 mmole/liter for the Duagh soil compared with 7 to 36 for the Malmo soil. Osmotic pressure values estimated from electrical conductivity ranged from 0.72 to 21.60 atm for the Duagh soil and from 0.20 to 0.94 atm for the Malmo. When the moisture content changed, no appreciable change occurred in the pH of equilibrium solutions of either soil.

Inherent soil characteristics and plant growth—High osmotic pressure of the soil solution appears to be the inherent soil characteristic most likely to restrict plant growth on Solonetzic soils.

In spite of wide differences in the chemical composition of the saturation extracts of a Black Solonetz soil (Duagh Si. L.) and a field associated Eluviated Black Chernozem (Malmo Si. L.), no significant difference was found in the ability of barley seedlings to grow on the untreated saturation extracts of either soil. Sodium and magnesium sulfate added to extracts of the Duagh soil depressed seedling growth, but the addition of equivalent amounts of sodium and magnesium chloride and potassium sulfate did not. No clear evidence could be established to suggest specific ion toxicity in the soil solutions.

Simulated deep plowing—Alfalfa grown in the greenhouse on mixtures of equal quantities of the A, B, and Csk horizons of seven Solonetzic soil types, generally, produced more dry matter than when grown on samples of individual horizons. The exceptions were confined to samples of A horizons, as growth on B and especially Csk horizons was quite restricted. Where the soil was subjected to moderate leaching after mixing, the yield was always reduced.

Soil mixing greatly changed the physical properties of the overall mass. For example, the average breaking strengths of the A, B, and Csk horizons were 2.47, 17.28, and 36.55 tons/ft^3 compared with only 4.71 tons for the soil mixture.

Deep plowing—Beneficial effects of deep plowing Duagh Si. L. Solonetz soil were previously reported. In the fall of 1966 four other Solonetzic soil types were plowed 22 inches deep. In 1967 on all of the soil types the yield of barley from the plots that were deep plowed was highly significantly greater than the yield from plots that received normal tillage. The long-term effects of this treatment will be studied.

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[3] Seconded from Economics Branch, and on leave to FAO, September 1967.
[4] Seconded from Departmental Library.
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G. E. Laliberte, B.Sc., M.Sc., Ph.D. Resigned August 1967	Drainage engineering
S. H. Pawlowski, B.Sc., M.Sc. Transferred to Research Station, Saskatoon, Sask., July 1967	Oil seeds

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M. R. Khan, B.Sc., M.Sc., Ph.D. National Research Council postdoctorate fellow, September 1966 to October 1967	Insect nutrition
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[13] Transferred from Research Station, Charlottetown, P.E.I., January 1967.
[14] Appointed September 1967.
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INTRODUCTION

The Research Station continued its development in servicing the four major types of agriculture in southern Alberta: tallgrass range of the eastern slopes of the Rocky Mountains, shortgrass range of the Great Plains, dryland cereal farming, and irrigated mixed farming on the best soil types of the plains.

A soil microbiologist was appointed to supplement our research in soil–plant relationships. Initially, research into the form of nitrogen in grassland soils will assist in determining their nitrogen requirements. As the research progresses, consideration will also be given to irrigated cultures.

After some years, our need for a mathematician has been met. One was appointed during the year. He, together with our computer systems programmer, is filling many of our local mathematical requirements. He keeps in close contact with the Statistical Research Service, Ottawa.

Detailed scientific accounts of completed research are in the publications listed. Reprints usually may be obtained directly from the authors. Other research reported is in progress. Further information on these subjects may be obtained by writing to the appropriate scientist or to the technical liaison officer.

T. H. Anstey
Director

PLANT SCIENCE

Wheat

High yields on irrigated land—Soft white spring wheats of local origin were tested for yielding ability against numerous introductions from the United States and a few from Mexico. Over a 6-year period one line, from the cross Exchange × (Kenya × Lemhi[2]), yielded 40% more than Lemhi 53, and 27% higher than Kenhi. In a 2-year comparison it has outyielded Lermo Rojo, Yaqui 54, and Nainari 60. Heavier fertilizer and water applications will be used in future to determine the maximum production capacity of these and other varieties for irrigated land in southern Alberta.

Winter wheat introductions—A continuing evaluation of many winter wheat genetic stocks indicated that most foreign varieties are not winterhardy enough for Western Canada. The winterhardy exceptions are all of Russian origin. Among these Petrovskaja 7 and Stepnaja 135 are high in yield, resistant to lodging and shattering, and early in maturity. Bezostaja 1 and Mironovskaja 264 are slightly lower in yield and hardiness than Petrovskaja 7 and Stepnaja 135, but are early maturing and have particularly strong straw. Uljanovka is winter hardy but later than the others in maturity. All are susceptible to common bunt.

Range Forage

Improvement with fertilizers (23)—The character of the vegetation was changed in Mixed Prairie range fertilized with N and N plus P applied by an increasing-rate spreader at medium and high rates, but not at low rates. Fertilizer application increased palatability of the vegetation and increased rangeland production by about 300% at low rates and about 900% at high rates. The latter encouraged invasion and increase of undesirable species. Since the long-term effects of vegetation changes are unknown, only low rates of fertilizer application can be suggested for the rangelands of southeastern Alberta.

Performance of crested wheatgrass (52)—Stands of crested wheatgrass, *Agropyron cristatum* (L.) Gaertn., from 29 to 38 years old, consistently outyielded the grass and sedge component of Mixed Prairie range vegetation by up to 12 times. Analysis of soils showed that exhaustion of N was not a factor in the persistence of stands. The data indicated that, in southeastern Alberta, seeded stands of crested wheatgrass become a permanent part of the vegetation and that yield is dependent mainly on current rainfall.

Chemical composition and digestibility (51)—In all plants studied, including five native and three introduced grasses, one

sedge and four shrubby species, in the *Stipa-Bouteloua* prairie at Manyberries, Alta., the amounts of P and digestible and crude protein decreased with maturity, while the cellulose increased. Introduced grasses generally contained more crude protein than native grasses. Shrubby species were higher in crude protein and P than native grasses. No consistent trend was observed in relative total ash and Ca content at progressive stages of development. The estimated nutritive value index was high for all grasses and low for two *Artemisia* species. The seasonal declines in crude protein and P suggested that protein and P supplements are desirable for range cattle during the fall, winter, and early spring.

Floral initiation and seed production in rough fescue (22)—The examination of 3,780 shoot apices of rough fescue, *Festuca scabrella* Torr., over a 3-year period showed that the seed crop of the next year can be forecast by sampling in the autumn. Initiation and partial floral development occurred in the autumn of 1963 and 1965; seed set in native stands was good in 1964 and 1966. Initiation failed to occur in 1964 and 1966; seed set was poor in 1965 and 1967. The tendency of *F. scabrella* to decrease in abundance when grazed heavily was attributed to its erect growth habit and lack of lateral tillers rather than to factors associated with the developmental morphology of the shoot apex.

Vegetables

Concentrated fruit maturity in tomatoes—A new multiple-truss character recently found in tomatoes may aid in the development of a variety with a heavy concentration of ripe fruit, which is desirable for the economic use of manual labor or in one-harvest operations with mechanical harvesters. With this character, concentrated maturity of 20 to 40 fruit occurs in a cluster between the sixth and seventh leaves in dwarf tomato plants. The fruit size of 1 to 1.5 inches of the original selection was increased to 2 inches in a backcross program and further increase may be obtained. Inheritance tests have indicated that this concentration of mature fruit is a recessive, monofactorial character not associated with the gene for compound flower truss that has been known for some time.

Limelight green-shell bean—Recently we released the variety Limelight as an early maturing snap bean, *Phaseolus vulgaris* L., with seed characteristics resembling those of the lima bean, *P. lunatus* L. Because of its similarity to the lima, this bean may be grown and processed as a green-shell bean in regions too cool for adequate growth of the lima. Limelight may be sown at the normal time for sowing snap beans because it does not require the high temperature for early growth as does the lima. The beans are ready for harvest about 70 days after sowing and yield more than 1.2 tons/acre. The rapid development of side-wall fiber contributes to the ease of shelling with mobile pea viners. In the processed state Limelight is difficult to distinguish in appearance from the lima bean and has an acceptable flavor.

Determination of fiber content in snap beans (24)—A washing apparatus was designed to speed up the washing of other plant material from fiber in determining the fiber content and related quality of green and wax beans. With this apparatus the washing time averaged 25 min for a set of 12 samples. One man would require about a day to wash the same number manually.

Quality evaluation of beans and peas (69, 70)—On the basis of quality and yield of 14 varieties of green beans tested, White Seeded Tendercrop, Bush Blue Lake, and Gallatin 50 proved best for canning and freezing in southern Alberta. Slimgreen was acceptable for canning but not for freezing. Of the four wax bean varieties tested, Earliwax, Resistant Kinghorn, and Puregold were suitable for canning and freezing. Quality in snap beans was best evaluated by taste panel rankings and amounts of total solids in seed and whole pod. The next best criterion was fiber content, especially for evaluation of breeding material.

Of 10 varieties of green peas tested for quality and yield, Cascade and Scout ranked highest for canning and Freezer 626 and Scout for freezing. Size classification was not correlated with quality in most of the varieties tested.

Control charts for food processing (68)—The practical use of charts for quality control in food processing was described. Control charts can be based on variables sampling by setting limits on the dispersion of a continuous variable about the mean (e.g., fill-weight), or on attributes sampling by setting limits on the number of times some quality factor occurs (e.g., defective labels).

Weeds

Growth of foxtail barley (58)—In greenhouse studies, foxtail barley, *Hordeum jubatum* L., when grown alone, developed best under high soil moisture, high soil fertility, and low soil salinity. On wet, nonsaline soils its growth was restricted by competition from orchardgrass, *Dactylis glomerata* L. On wet, saline soils, where orchardgrass offered little competition, foxtail barley developed freely. It developed only sparsely on dry or infertile soils. *Agropyron elongatum* (Host) P. B. prevented development of foxtail barley on wet, saline soils, and *Festuca arundinacea* Schreb. and *Phalaris arundinacea* L. restricted its development to a high degree. Growth of foxtail barley was enhanced as soil temperatures were raised from 7 C through 12 C and 20 C to 27 C.

Control of aquatic weeds—All native aquatic plants except *Chara* spp. were controlled to some degree by diquat and endothall in lake plot experiments at Lethbridge, Alta., and Regina, Sask. A compressed-air injection system was designed to increase the effectiveness of the herbicide by releasing it just above the aquatic vegetation about 18 inches below the water surface. Analyses of water treated with diquat indicated that it persisted for only 24 to 36 hr under the prevailing conditions. Control and persistence in irrigation water must be determined.

PLANT PATHOLOGY AND PHYSIOLOGY

Snow mold (33)—Snow mold of forage crops and turfgrasses on the Canadian prairies is caused almost exclusively by a ubiquitous psychrophilic sterile basidiomycete that causes significant damage every season. The disease on alfalfa has been controlled in field experiments by foliar sprays of borax. The relationship between development of snow mold on alfalfa and the accumulation of toxic amounts of HCN in the crown buds has been established. In contrast to unsprayed alfalfa, plants sprayed with borax and inoculated with snow mold pathogen did not accumulate toxic amounts of HCN in their crown buds. In in vitro tests borax did not inhibit the hydrolysis of amygdalin by an enzyme preparation from the fungus. When incorporated into the media, however, borax inhibited the formation of HCN by a normally cyanogenic isolate of the fungus. These results indicated that the borate ion absorbed by the alfalfa foliage may act by interfering with the synthesis of a cyanogenic compound in the host rather than by inhibiting the enzymic release of HCN.

Nematode diseases (14)—Bacterial wilt, *Corynebacterium insidiosum* (McCull.) Jensen, appears to inhibit infestation of alfalfa by the stem nematode, *Ditylenchus dipsaci* (Kühn) Filipjev. In the first of a series of tests, 72% of a population of healthy Grimm alfalfa plants became infested compared to 32% of a population in which bacterial wilt had developed for 3 months before inoculation with nematodes.

So far, neither Roamer nor Rambler alfalfa, both susceptible to infestation by the stem nematode, has shown more than a slight loss in wilt resistance when exposed to nematodes and wilt bacteria in the greenhouse.

A spray application of thionazin to the soil surface was effective in controlling alfalfa seedling infestation by the stem nematode in greenhouse pot experiments. The compound does not show promise as a chemotherapeutic under our test conditions.

A practical bioassay technique has been devised to detect viable cysts of the sugarbeet nematode in soil.

Wheat streak mosaic (3)—Data gathered during a severe outbreak of wheat streak mosaic in the 1963–64 winter wheat crop was analyzed to determine the losses caused by this virus disease. A detailed study of a 24-acre moderately affected winter wheat crop in the Lethbridge area was made and the mathematical relationship between disease intensity and yield was calculated. Knowledge of this kind is needed in appraising streak mosaic losses and as a guide for evaluating the yield prospects of mosaic-infected crops. The data also indicated that the reduction in yield caused by streak mosaic resulted from a marked reduction in the number of kernels formed by infected plants and from the production of kernels that were smaller and lighter than those from healthy plants.

An extensive acreage survey carried on concurrently with the detailed study showed that about one-quarter of the 1963–64 winter wheat crop was infected with streak mosaic. Estimated losses for the acreage surveyed exceeded 700,000 bu, or 18% of the potential yield.

The effect of rapeseed residue on cereal production—Rapeseed residue deleteriously affected growth of cereal crops in the Vulcan–Nanton area of southern Alberta. Yields of wheat, barley, and oats were reduced and their maturity was delayed. Comparisons were made between crops grown on 3-ft-wide strips where the combine harvester had discharged rapeseed residue the previous year and crops grown on the intervening 12-ft strips. In 1966, Echo rape, which yielded 27 to 30 bu of seed/acre, left about 3.50 and 1.33 tons/acre of residue in the discharge and intervening strips. An estimated 50 to 60% of this residue remained on the soil surface in August 1967. Loss in yield of the cereals was caused by stunting of the plant and not by a reduction in their number. The loss in yield was apparently caused by either a toxin from the residue or an unfavorable nutrient balance. Occurrence of common root rot, though slight, was significantly reduced by the heavy residue layer.

Soil-borne pathogens—In recent years, several hundred acres of irrigated land in southern Alberta have been withdrawn from pea growing because of a high infestation with pea root-rot pathogens. *Pythium ultimum* Trow is the main cause for preemergence rot of wrinkle-seeded peas in this area, and in warm soil *P. aphanidermatum* (Edson) Fitzp. is a contributing factor. Rhizoctonia stem rot, although not usually of economic importance, caused considerable damage to young plants in 1967. The severity of root rot was reduced 20% and the yield was doubled when pea seed treated with captan was grown in soil receiving an "in-furrow" application of the experimental fungicide du Pont 1991. This fungicide, although highly effective on soil, was ineffective as a seed protectant.

Wheat leaf phosphatases—Some of the wheat leaf phosphatases have been partially separated from each other by gel filtration on Sephadex G-200. Some of these enzymes appear to be composed of enzymatically active subunits capable of association and dissociation. An acid pyrophosphatase has been separated from the other acid phosphatases. This enzyme also hydrolyzes phenolphthalein diphosphate, *p*-nitrophenyl phosphate, and phenyl phosphate. The leaves contain at least one other enzyme that hydrolyzes pyrophosphate.

CROP ENTOMOLOGY

Grasshoppers

Survey—In Alberta, grasshoppers have been increasing in numbers since 1966. The infestation in 1968 is expected to cover 8,975 sq miles, 700 more than the 1967 infestation. Heaviest infestations are expected to occur in the area immediately northeast of Lethbridge and in other areas southeast of Lethbridge.

Control (35)—The oral toxicities of 23 organochlorine, organophosphorus, and carbamate insecticides were tested by

feeding lettuce discs bearing measured amounts of insecticide to weighed fifth-instar nymphs of *Melanoplus bivittatus* (Say), *M. sanguinipes* (F.), and *Camnula pellucida* (Scudder). Grasshoppers collected from locations widely separated geographically did not differ in their susceptibilities to the insecticides indicating that natural selection for resistant strains had not occurred. Because field-collected grasshoppers were more susceptible to insecticides than were laboratory-reared grasshoppers uniform rearing conditions are needed to establish base-line toxicity data. There is a possible danger in the direct application of laboratory data to field control. Recommendations for control should take into account the species to be controlled because the study showed variations in susceptibilities among the species tested. Methyl parathion and Baygon were the two most effective insecticides tested.

Nutrition (36)—Fifth-instar nymphs of *M. sanguinipes* were fed diets containing various proportions of cellulose powder and wheat-sprout meal. Although the grasshoppers were unable to digest cellulose, they made normal weight gains on diets containing as much as 90% cellulose by increasing their consumption so that their intake of nutrient remained constant. The increase in inert components in the diet did not reduce the effective utilization of the nutrients it contained. These results contrast with those from tests with the mouse and the chick, neither of which can adjust its food intake to compensate for low concentrations of dietary nutrients.

Cutworms

Survey—Populations of the pale western cutworm, *Agrotis orthogonia* Morrison, decreased rapidly after 1965 because of above-normal rainfall. In 1967, infestations were low and practically no damage occurred. No marked increase of this cutworm is expected unless droughts occur in the prairie region in the next 2 years. In 1967 considerable damage from the red-backed cutworm, *Euxoa ochrogaster* (Guenée), occurred in the Peace River region of Alberta and areas adjacent to Edmonton. A recurrence of infestations is expected in these areas in 1968.

Damage by cutworm larvae (20)—Larvae of *A. orthogonia* feed on plants just below or at the soil surface. They usually damage spring wheat more than winter wheat because the winter wheat is more advanced in growth when the larvae are feeding. Larvae, however, were found to cause heads of winter wheat plants to be sterile or to contain only shriveled kernels. This damage was caused by the mature larvae severing or partially severing the stems. The feeding on mature tissues of the wheat stems is believed to come from the habit the larvae have of eating exceptionally large quantities of food materials, even blotting paper when it is provided, just before they end their feeding period.

Nutrition (25)—Larvae of *A. orthogonia* were reared on an artificial, partly defined diet that contained neither extracts nor parts from green plants. Deletion of niacinamide, choline chloride, calcium pantothenate, and pyridoxine from the diet stopped growth and development of larvae in the second- and third-instar. Larvae developed to the fifth-instar with deficiencies of riboflavin, folic acid, or thiamine, but were unable to pupate. Larval growth was strikingly retarded by a deficiency of thiamine. Inositol, biotin, or vitamin B_{12} had no apparent effect on growth and development.

Pollinating Insects

The alfalfa leaf-cutter bee (67)—The imported species *Megachile rotundata* F. has been demonstrated to be a valuable and essential pollinator of alfalfa in some areas of Canada. Our research has shown how to rear this bee in specially constructed nests. Proper management results in a rapid increase of its numbers. Since the bees cannot survive Alberta winters, we have shown that they must be removed from the nests and stored at 40 F. Incubation in trays at 85 F for 20 days just before the alfalfa flowers begin to emerge optimizes the bee population at full bloom. Parasites are removed and destroyed during incubation.

Bee activity is threshold temperature dependent. It has been found that 350 hr with temperatures above 69 F during the pollinating period of alfalfa are required

for satisfactory pollination. Care must be taken to protect the bees from insecticides, ants, birds, and small mammals. For adequate pollination one shelter containing at least 40,000 bees is required for each 4 acres of alfalfa.

Plans for equipment and specific methods for obtaining and handling the bees have been developed and field tested.

Managing bumblebees that pollinate red clover (18)—Colonies of bumblebees obtained by placing false underground hives (hives placed on the soil surface with tunnels attached to their entrances) in the areas where numbers of bumblebees are large were found to be less costly than setting out underground hives. False underground hives attracted more queens of surface-nesting, versatile, as well as underground-nesting species than the surface hives. Colonies in the hives may be protected from flooding, ants, and mammals by placing the hives on posts surrounded by moats. Further research is required to learn how to prevent attacks by the cuckoo bees of the genus *Psithyrus*.

Ecology of Pyrobombus (19)—The 11 species of *Pyrobombus* that occur in southern Alberta were compared for their distribution, micro- and macro-habitat, period of nest establishment, and behavioral habits. Most of the behavioral patterns were common to all species and some indicated close relationships among certain species. One pattern was common to species in two subgenera, but only to 4 of the 11 species of *Pyrobombus*, which indicates evolutionary trends. The major insect enemies were found to be three species of cuckoo bee of the genus *Psithyrus* and, in certain years, *Volucella bombylans* (L.) (Diptera: Syrphidae).

Other Insects

Oviposition medium for cabbage maggot (56)—The cabbage maggot, *Hylemya brassicae* (Bouché), can be readily reared in the laboratory. Recently the following improved method of obtaining eggs was developed. Keep the adult flies in plastic cages and provide them with food. Place a strip of blotting paper rolled into a coil about a wick of absorbent cotton in a small beaker. Immerse the wick in a solution of rutabaga root extract to act as an attractant. The extract may be stored frozen for a least 2 months. The eggs are deposited on the coil, between the layers of the blotting paper, or between the coil and the beaker. Remove the coil and the eggs, which are readily visible, and count them or remove them for incubation or other treatments.

Sex attractant for wireworms—We have previously demonstrated that virgin females of the sugar-beet wireworm, *Limonius californicus* (Mannerheim), produce a chemical that attracts males of the species. This attractant has now been isolated and identified as valeric acid. Although pure valeric acid repels males, a dilute solution of it attracts them. In the field the solution attracted males from a distance of 40 ft. The chemical occurs in unusually large amounts in the body of the female, probably in bound form, and is released in the free form as needed. Many other organic compounds tested in the field were shown to be ineffectual.

This work involved a joint project with members of the USDA, Beltsville, Maryland, and was initiated by us.

ANIMAL SCIENCE

Beef Cattle

Brahman–British beef cattle crossbreds (39)—The performance of three Brahman-sire progeny groups was better than that of contemporary Herefords. Brahman × Angus and Brahman × Shorthorn cows surpassed other groups in weaned calf percentage. Hereford calves were lighter than F_1 and heavier than 1/4-Brahman calves at birth. In each generation all classes of part-Brahman calves were heavier ($P < 0.01$) at weaning than the control Herefords. The calves from the F_1 cows were 34 to 45 kg heavier than Hereford calves, and the calves from 1/4-Brahman cows were 18 to 34 kg

heavier than the controls. Crossbred cows weighed 36 to 55 kg more than Hereford cows at weaning time and their calves weighed an average of 36 kg more than Hereford calves.

Twenty-six Hereford and 22 Brahman × Hereford cows, born in 1952–54, were retained to compare their longevity under range conditions. By December 1967, there were 2 Herefords and 12 crossbreds still in the herd.

Fertilized native range for livestock (7)—Chemical composition, nutritive value, and silica content of forage from an area of native prairie containing 80% *Festuca scabrella* Torr. were related to the nutritive requirements of the beef animal. The area was fertilized with N and P at increasing rates. Forage samples were collected at the heading stage, 1 and 2 years after fertilizer application. A significant negative correlation ($r = -0.68$, $P<0.01$) existed between the percentage of protein and the percentage of silica in the forage. This and other data indicated that a protein content of 16% would be required to prevent the formation of uroliths in cattle. Phosphorus in the forage was adequate for beef cattle nutrition when P was applied at 200 kg or more per hectare. Percentage of cellulose in the forage was less ($P<0.01$) from plots fertilized in 1962 than from plots fertilized in 1961. The percentage of cellulose also decreased ($P<0.01$) with increasing rate of fertilization. However, the percentage of digestible cellulose and nutritive value index were not affected by level or year of fertilization.

Antibloat compound (6)—Poloxalene, a nonionic surfactant, was fed to beef cattle on a legume ration, to beef cattle on a high grain ration, and to lactating dairy cows. It proved to be beneficial in the prevention of bloat with both legume and grain rations. Poloxalene had no effect on the percentage of fat, protein, solids-not-fat, or yield of milk.

Nutrition and Management

Slatted floors for beef cattle (66, 74, 75)—A survey of 10 slatted-floor beef barns showed that concrete slats were more effective than wooden slats and that excess moisture within the building became a problem only when ambient temperatures fell below 0 F. Differences in daily gain between open-yard and slatted-floor barns varied depending upon management. However, gains of up to 3.3 lb/day with a 6- to 9-lb conversion equivalent were experienced.

Costs of operating averaged 7.5 cents per head per day, less a manure credit. Feeding costs varied depending upon the type of feed used. Silage cost about 2.5 cents less per pound of gain than grain. This advantage is partially offset by higher investment costs for storing silage and mixing than for storing grain only.

Protein supplement for range cows—Twenty cows fed 3.5 lb of a 25% protein supplement twice per week gained 23 lb each from December 8 to April 8. Cows fed 3.5 lb of a 5% protein supplement twice per week gained 3 lb each during the same period. The two supplements were formulated to supply about the same amount of digestible energy. The birth weights of the calves were not affected by the protein supplement.

Concentrate level for feeding dairy cows—Cows were fed 0.15, 0.25, 0.35, and 0.45 lb of a concentrate mixture (oats 46%, barley 20%, bran 19%, soybean oil meal 7%, molasses 5%, mineral and vitamin A 3%) per pound of milk produced.

Cows fed 0.35 lb of concentrate per pound of milk produced the most milk, followed by those fed 0.45, 0.25, and 0.15 lb. Total protein and solids-not-fat production closely paralleled total milk production. Fat production varied and its pattern differed from that of total milk production.

The milk produced per pound of total feed consumed generally declined as the rate of concentrate intake increased. However, the cows on the low rate of concentrate feeding generally lost weight and those fed the 0.35- or 0.45-lb level of concentrate gained weight. Average changes in body weight in the 6-week period were −25, −6, 8, and 8 lb for cows fed the 0.15, 0.25, 0.35, and 0.45 levels respectively. Body-weight changes may not reflect the total change because there may be changes in body fill and composition that occur simultaneously with change in

body weight. Although milk production per unit of feed intake was greatest at the 0.15 level of feeding for the 6-week periods used in this experiment, these data should not be extrapolated to an entire lactation.

Physiology

Solids in cattle urine—The nondialyzable solids in cattle urine were separated into an ultrafilterable fraction, pore size 10 to 20 mμ; a nonultrafilterable veronal-soluble fraction; and a nonultrafilterable veronal-insoluble fraction. The concentration of each fraction was greater in cattle fed prairie hay, which predisposes to silica urolithiasis, than in cattle fed alfalfa hay. In cattle fed prairie hay, the concentration of the three fractions of the nondialyzable solids and the concentration of silicic acid were greatest at low rates of urine excretion. The concentration of silica in each fraction of the nondialyzable solids was greater in cattle fed prairie hay than in those fed alfalfa hay.

Control of silica urolithiasis (4)—The ratio of water to feed intake increased in steer calves fed calculogenic rations with 3% NaCl, with 0.5% NH_4Cl, with water administered via rumen fistulae to equal the water intake of the 3% NaCl group, and with 3% $NaPO_3$ when compared with that of steers fed a control ration. The group receiving the added NaCl produced the fewest cases of urolithiasis and the lowest weight of calculi per affected animal (21.6 mg). Next in order were the group receiving additional water (61.4 mg), the control group (143.0 mg), the sodium hexametaphosphate group (237.4 mg), and the NH_4Cl group (262.1 mg). All calculi produced in animals receiving sodium hexametaphosphate were phosphatic, whereas those produced in the other groups were siliceous. The results indicated that increasing the intake of NaCl or water, or both, reduced the incidence of urolithiasis, whereas NH_4Cl and sodium hexametaphosphate did not.

Poultry Nutrition

Selection for body weight at different ages—Broilers selected only for early rapid gains to 9 weeks of age weighed 17% more at maturity than the unselected control group. A strain developed from selection for high 9-week and low 21-week weight averaged 18% heavier at 9 weeks than the controls with no measurable differences in mature body weight. Early growth can be increased without increasing the size of mature birds and the increased cost involved in maintaining a large bird can be avoided.

Phosphorus requirements of replacement pullets—An inorganic P level of 0.45% in the diet as required by National Research Council (USA) was shown to be unnecessary during the rearing period or for subsequent egg production in Single Comb White Leghorns and broiler-strain pullets. Use of a type of wheat–soybean meal feed with 0.1% and 0.2% P supplement resulted in no better growth than an unsupplemented diet.

VETERINARY–MEDICAL ENTOMOLOGY

Face Flies

Distribution of the face fly, *Musca autumnalis* DeG., has been under surveillance for 3 years to assess its potential as an economic pest of cattle in Western Canada. Surveys in August 1967 showed heavy infestations throughout British Columbia south of Williams Lake and including Vancouver Island. Invasions progressed northward in western Manitoba and eastern Saskatchewan to the latitude of Yorkton. Populations moving through the Crowsnest Pass have infested the foothills region of Alberta between Calgary and Waterton National Park. Distribution in the Prairie Provinces is limited so far to the parkland with some isolated pockets in scrub-covered localities such as Moose Jaw, Sask.

Hematophagous Flies

Behavior—It has been shown by use of fluorescent marking that adult horn flies, *Haematobia irritans* (L.), move from animal to animal within a herd. The behavior pattern suggests a potential economic

modification in fly control in which selective treatment of animals with effective residual pesticides may provide practical fly control for an entire herd.

Studies on the embryology of *Aedes vexans* Meigen and *A. sticticus* Meigen were started to distinguish environmental conditions critical to the hatching of eggs. Alternating regimes of temperature are required to stimulate development of eggs below 20 C. Optimum development is obtained between 20 C and 25 C and embryos are killed at 33 C.

Unusually high rates of parasitism have been found in *A. vexans*. Mermithid parasites infecting larvae in the Mission City and Haney areas of British Columbia caused 100% mortality in newly metamorphosed adults.

Vectors of Viruses

Collaboration with the Alberta Public Health Laboratory continues with emphasis on the biological mechanisms contributing to the survival of Western Encephalitis virus in Alberta. Infection of domestic chickens used as controlled indicator animals for 4 successive years showed that the virus is normally active in bird populations exposed to biting flies in southern Alberta irrespective of occurrence of epidemic infections in horses and man. Current investigations on hibernating species of mosquitoes and of wild mammals are in progress to identify overwintering reservoirs of infection that maintain the virus endemically in the region.

Warble Flies

Histology—Examination of bovine tissues at loci of invasion by newly hatched larvae of *Hypoderma lineatum* (de Villers) showed extremely dense areas of cellular infiltration. These areas were concentrated primarily around blood vessels. They were predominantly eosinophilic, although smaller areas of lymphocytic infiltration occurred also. Vessels associated with arteriolar constriction contained primarily neutrophils and lymphocytes. The epidermis was necrotic at the point of invasion and an amorphous exudate containing eosinophils and pyknotic neuclei adhered to the skin surface. A number of hair follicles containing dense accumulations of eosinophils were examined from their base to the skin surface. The eosinophils were found to merge with the exudate. These observations associated with pinpoint hyperemia on the skin surface indicated that newly hatched larvae enter the skin through the hair follicles. Treatment of mature cattle with ACTH at the time of invasion by the larvae reduced the eosinophil count and variably reduced host resistance to invasion as measured by numbers of grubs surviving to cut the backs.

Serology—Gross serological examination of antibody titers in cattle have shown that immunological mechanisms respond to grub infestations. Studies are being extended to isolate and identify either antigens or substances present in warble larvae that contribute to the immunological response and to the natural resistance observed in older cattle with histories of exposure to infestation. Immunizing properties of various fractions of larvae are being assessed for use in a vaccine as an alternative to chemical control of grubs.

Similar studies are in progress to determine the nature of resistance to keds in sheep.

Host Resistance to Ectoparasites

In the tick *Dermacentor andersoni* Stiles survival of males but not of females was lower, and engorged females weighed less from sheep that had acquired resistance to keds, *Melophagus ovinus* (Linnaeus), than from ked-free sheep. Survival of ticks of both sexes was higher in April and early May on both ked-resistant and ked-free sheep receiving a ration without vitamin A than on sheep receiving vitamin A supplement. No difference in tick survival was found on similar sheep infested in late May and early June, nor on A-deficient and A-supplemented guinea pigs infested in June, July, and August. Engorgement time of female ticks increased from 7 to 8 days in April to 16 to 19 days in August. Two sheep on a ration without vitamin A developed tick paralysis from an April infestation.

Control of Livestock Pests

Chemosterilization—Oviposition was suppressed in mature horn flies, *H. irritans,* exposed to residues of Apholate. Counts of eggs from treated flies in comparison with control flies indicated reductions of 38 to 69% for exposure by tarsal contact and 53 to 80% for exposure to a 10% sucrose bait on pledgets. Apholate had no effect on hatching rate because test flies mated and females were gravid before treatment.

Toxicology — Reproductive functions were disrupted in female mice treated with dermal applications of a systemic pesticide. Two treatments with Ruelene at 50 or 100 mg/kg in a 2-week period had no effect on rhythmicity in the estrous cycle, but suppressed the mating response. Mating was reduced to 30 and 50% after treatment with the lower and higher doses respectively. Only 10% of mice treated with either of the two doses became pregnant. Females treated at the higher dose produced no litters. Mice that became pregnant after treatment with the lower dose produced viable litters. The number of young mice born of females treated with the lower dose was 13% of those born of untreated females.

Chemical control—Pour-on formulations of 8% trichlorfon and 2 and 3% fenthion were applied to groups of 25 weanling calves at 0.5 oz/100 lb body weight for control of *H. lineatum* and *H. bovis* (L.) in late October. A water-miscible formulation of 10% fenthion was added to the drinking water of other groups of calves at the rate of 15 ppm for 6 days. To span the stress period for shipping fever one of two replicate sets of calves was treated on arrival at the feedlot and the other 10 days later. The trichlorfon pour-on and fenthion water-miscible treatments were equally effective at 96 and 93% respectively. Lower levels of grub control at 91 and 72% were achieved with the 3 and 2% fenthion formulations respectively. Treatments were equally effective against both species of grubs and no side effects were observed. No difference in the incidence of shipping fever in subgroups was detected between treated and untreated calves. These tests gave no indication that stress of systemic treatment for grubs is a factor contributing to shipping fever.

SOIL SCIENCE

Soil and Crop Management

Fertilizer experiments and soil testing (9)—Fertilizer trials provide the basis for soil test interpretations. Numerous experiments are required with each crop to obtain reliable data. Such data are slowly emerging from work conducted with various irrigated crops. This information has been utilized in the Alberta Soil and Feed Testing Laboratory at Edmonton in making fertilizer recommendations for the irrigated area. As more research data become available they will be used to refine the recommendations.

Annual application of NH_4NO_3 over a 5-year period increased the K as well as the N content of bromegrass growing on a Black Solonetz soil. The Na, Al, and Fe contents of the grass were reduced. Application of fertilizer significantly reduced the Na content of the A horizon.

Conservation practices (2)—The quantity of cereal residue (trash) conserved on the surface during primary tillage with a wide-blade cultivator was about 10% higher on 4-inch than on 12-inch stubble. Conservation was up to 25% higher at high speed (5 mph) than at low speed (3 mph) in a firm, moist soil. Good straw clearance at the blade standards resulted in good trash conservation. The differences were not measurable after three operations. Generally, the blade conserved 85, 90, and 95% of the pretillage residue during the first, second, and third operations respectively, and stubble was left upright after the first and second, but was frequently flattened during the third operation.

In recent years, difficulty has been experienced in establishing good stands of sweet clover. The results of field surveys

and of a controlled experiment showed that agronomic practices have been largely at fault. It has been found that when legumes are seeded with a companion crop in a single operation the small seed is placed too deep. Results have confirmed that small-seeded crops such as sweet clover must be seeded into a firm seedbed at a shallow depth to germinate satisfactorily.

Biomagnetism and soil volume (40, 41, 53)—Pregermination exposure of winter wheat seed to magnetic fields of less than 100 oersteds resulted in a stable temperature-independent enhancement of seedling growth rate. Subjecting dry bean seed to a 1,500-oersted field for 240 hr and seeding with their micropylar end toward the geomagnetic north pole improved the total single-harvest snap bean yield by more than 20% and minimized the sieve-size distribution.

Measurements of top and root growth of three crop species showed a consistent relationship between growth and soil volume. When root systems were crowded, it appeared that each root interfered with the water supply of nearby roots, and water intake and growth of the whole plant were restricted. It is concluded that in experiments involving nutrition or soil moisture content the soil volumes are often too small to permit maximum effects of the treatments.

Soil Salinity, Irrigation, and Drainage

The Gen atmometer (50)—An atmometer was designed to provide accurate evaporation data and to eliminate several undesirable features common in other atmometers. Among these features are frost damage, flooding in high winds, and the necessity of daily readings. Evaporation readings from the Gen atmometer correlated closely with those obtained by two other widely used types.

Evaporation from soils with a high water table (49, 54)—Lysimeter studies in southern Alberta indicated that if the rainfall between June and November was 15 cm or more a net downward movement occurred under bare clay–loam soil. If the water table was deeper than 1 m, all the water that migrated upward during the winter could be recovered in the spring. A net annual upward movement resulted when the depth to the water table was less than 1 m.

Rising barometric pressure was found to cause water to move temporarily into lysimeters having water tables controlled by mariotte reservoirs. Laboratory measurements confirmed the field observations. This effect precludes the use of mariotte readings for correlation with daily meteorological measurements.

Irrigation (16, 26, 27)—Efficiency of water use by an irrigated sward of orchardgrass, creeping red fescue, and bromegrass was increased with increasing N fertilizer but not P fertilizer. Yield increase from fertilizing was relatively greater than the increase in evapotranspiration. When total dry-plant material exceeded about 1.8 tons/acre, evapotranspiration increases with increased crop size were relatively small. The greatest daily rates of crop growth and the most efficient use of water occurred in midsummer on plots fertilized with N at 375 lb/acre. The relationship between evapotranspiration and solar radiation expressed as evaporation equivalent was similar to that reported for similar crops in the Western United States.

The method of irrigation did not appreciably affect yield and quality of tomatoes, potatoes, and peas provided that the soil was supplied with sufficient water at the right time. However, when picking seasons were hot, sprinkling slightly delayed maturity and ripening of tomatoes. Timing of irrigation with respect to day or night was of very minor importance.

Shallow unlined moles as irrigation distribution channels were not successful for two medium-textured soils (Chin and Lethbridge). The main problems are the critical soil moisture required for formation of a stable mole and the comparatively slow lateral and vertical moisture movement from the point of application. With these limitations efficient irrigation could be achieved only from moles spaced 4 ft apart and approximately 10 inches below the soil surface.

Saline soils (17, 48)—Recent experiments have shown that the application of more water than that required for crop growth was necessary to prevent gradual accumulation of salts at or near the soil surface. The accumulation may reach

levels deleterious to crop production. Although this principle applies for all methods of irrigation, the inherent water control possible under sprinkling normally discourages overirrigation, and the leaching requirement is frequently neglected.

Results indicated that sufficient salt removal for reclamation of sloping land was attained with border-dike irrigation where deep (5 to 6 ft) tile drains were installed. However, shallow (about 30 inches) tiles placed on top of the glacial till were nearly as effective as the deep drains, mainly because of the low hydraulic conductivity of the glacial till.

Seepage control in irrigation ditches, canals, and dugouts (30, 42)—Observations of four lining materials over 10 to 16 years indicated that polyethylene plastic controlled seepage best. Asphalt and concrete (shotcrete) gave intermediate and similar control, whereas compacted earth linings were the least watertight. Concrete linings were the most costly, then asphalt, plastic, and compacted earth.

Seepage from a ditch lined with unreinforced concrete installed with a subgrade-guided slip form was reduced by more than 90% initially and was still greater than 70% after 3 years.

Soil Chemistry

Organic matter of Chernozemic soils (10, 11, 12)—Some of the characteristics of the organic matter in Orthic Chernozemic soil profiles of each of four parent materials from three climatic soil zones (Brown, Dark Brown, and Thin Black) have been compared. The polysaccharide carbon, determined by anthrone and expressed as a percentage of the total organic carbon, ranged from 1.8 to 2.7% in the Ah horizons and from 1.8 to 3.1% in the Bm horizons. Some six individual sugars were identified in the humin fraction of all soils. Rhamnose was present only in the Ah horizon of alluvial-lacustrine soils from all three zones. The inositol phosphate content in Chernozemic soils accounted for only a small proportion of the total organic phosphorus present. Generally, there were more of the lower phosphate esters than of the higher phosphate esters of inositol. The results indicated that the nature of the parent material, e.g., till, lacustrine, or aeolian, must be considered in any further studies of the composition of organic matter from soils.

The infrared spectral configurations in the region from 2,500 to 1,800 cm^{-1} were evaluated for humic acids from several soils formed under various vegetations. Apparently these configurations are related to the molecular weight of the humic acids and to the vegetation under which these materials were formed or transformed. The same results were obtained from soils formed under poplar and coniferous trees. During transformation from Chernozemic to Podzolic soils, the 'Podzolic character' of the infrared spectra first becomes evident in the Bt horizon.

Exchangeable sodium percentage and hydraulic conductivity (47)—The hydraulic conductivity of glacial till soils having mainly montmorillonite in the clay fraction was practically zero when the exchangeable sodium percentage (ESP) exceeded 15 to 20. Relatively higher permeability was obtained in similar soils containing gypsum, but these soils sealed above ESP of 30 to 35. The decrease in permeability from ESP and electrolyte content can be estimated only when results of experiments with soils of similar clay mineral content are available.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

If the Canadian Standards Association has not approved a common name for a pesticide, the trade name or temporary designation has been used as follows:

Trade name or designation	*Manufacturer*
Apholate	Olin Mathieson Chemical Corporation
Baygon	Chemagro Corporation
du Pont 1991	E. I. du Pont de Nemours and Company (Inc.)
Ruelene	The Dow Chemical Company

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INTRODUCTION

This report summarizes our main research findings and program for 1967. Research is conducted on dairy cattle, poultry, soils, forage crops, small fruits, and vegetables. A substation at Abbotsford is maintained for cultural experiments on strawberries and raspberries. In this report, none of this research is described in detail. In some cases, as with long-term projects, progress is outlined. Completed research is reported in more detail in the scientific papers and other publications listed at the end of this report. These are also indicated by numbers below the subheadings. Reprints of most articles are available from the authors.

M. F. Clarke
Director

[1] On 33-month FAO assignment in Iran, February 1967.
[2] Appointed October 23, 1967.
[3] On transfer of work at Scottish Horticultural Research Institute, Dundee, July 1967.
[4] Appointed March 23, 1967.
[5] Appointed June 26, 1967.

SOILS

Data Processing Approach to Soil Characterization

Soil characterization data have been collected from 110 soil series in the lower Fraser Valley. The data were coded and entered on punched cards, and a computer program was prepared to provide prediction values for available nutrients, moisture content, and adaptability of crops.

Distribution and Availability of Phosphorus in Fraser Valley Soils

Soil samples were collected from a sequence of varying degrees of profile development ranging from river sediment to more strongly developed gleysols. Representative samples were also taken from profiles of the marine and loess deposits of the adjacent uplands.

Fractionation of the soil P indicated that the P status of the soils varied with distance from the river and degree of soil development. Juvenile soils close to the river contained relatively large amounts of calcium-P and small amounts of iron- and aluminum-P. Soils located at some distance from the river exhibited a striking change in P status, organic-P and total P being much higher. In all profiles total and organic-P decreased with depth.

The soils developed from loess and marine deposits were high in aluminum-P and had only small amounts of calcium-P. These soils were also lower in organic-P than the recent Fraser River deposits.

Soil Analysis and Fertilizer Requirements

The main objectives in this work are to group soils according to their fertilizer requirements for growing crops and to relate the fertilizer requirements to the chemical status of soils. In the lower Fraser Valley region, the diversity of crops grown and the differences in fertility requirement among crops add greatly to the problem of estimating fertilizer needs.

In 1967, plot experiments with five crops were conducted on a Lickman silt loam. The data confirmed present fertilizer recommendations for soils medium-high in P, medium in K, low in Mg, and low in N-supplying power. The data also suggested that an early-maturing silage corn needs more Mg than a late-maturing variety does.

Lime Requirement of Fraser Valley Soils

The main objective of this study is to relate the lime needs of specific crops to the chemical nature of soils in the lower Fraser Valley. Growth-chamber experiments with alfalfa grown in seven contrasting soils have emphasized that all soils should not be at the same reaction (pH) or the same percentage base saturation for the best growth of alfalfa. Lime increased total yield about 500% on a Ladner silty clay loam (older lowland), 250% on a Whatcom silt loam (upland), but only 10% on Fairfield silt loam (recently deposited lowland). The pH values for each soil were similar.

VEGETABLES

Potatoes

29, 30

Cariboo, a new main-crop variety, was licensed for commercial production in 1967. Previously known as seedling F5561, Cariboo originated from a cross made at the Research Station at Fredericton, N.B., the National Potato Breeding Center. This variety has excellent quality for cooking and for processing, and its resistance to bruising and scuffing makes it well suited to mechanized handling.

A temporary license was recommended for the American variety Norgold Russet. This variety fills a need for an intermediate crop between the early and late varieties. Norgold Russet has been well accepted by growers and by the trade. It is rather specific in soil adaptation, however, and

produces a high incidence of hollow heart when grown in certain locations.

Potato seedlings resistant to the golden nematode were imported for trial in the quarantine area of Vancouver Island. In addition, *Solanum* spp. with susceptibility to specific strains of the golden nematode were introduced as a means of identifying the particular strain now on Vancouver Island.

Influence of Soil Moisture on Peas

10

Further progress was made in the study of the relationship between soil moisture stress in the plant and soil moisture supply. The 1967 results confirmed earlier findings that optimum yields could be obtained by subjecting pea plants to a moderate stress period before blossom and adequate soil moisture during and after blossom. Heavy irrigation to maintain a high soil moisture level throughout the cropping period resulted in excessive vegetative growth and no increase in yield of peas.

Growth Regulators for Peas

Cooperative experiments on the use of chemical regulators to control growth of peas have been continued at this station and at the University of British Columbia. It has been shown that a low concentration of Cycocel, 10^{-5} M, increases the yield of peas grown in the greenhouse, but that similar results were not obtained from field experiments. Extensive trials using TIBA on several varieties, at different rates and times of application, have shown that this chemical cannot be used successfully on peas. The application of Alar and Phosphon at low concentrations has been studied, but results have been inconclusive.

Maturity Estimation for Sweet Corn

Research on methods for evaluating maturity of sweet corn has shown that specific gravity is one of the most satisfactory criteria for defining the correct stage for processing. The accuracy of the specific gravity measurement was improved when the husked ears of corn were preblanched for 1 min at 100 C.

Herbicides for Vegetable Crops

Several herbicides were tested as preplanting, preemergence, and postemergence treatments for sweet corn, bush beans, carrots, brassicas, and potatoes. A very brief summary of the results follows. Rates are expressed as acid equivalent or active ingredient in pounds per acre.

Bush beans—Preemergence treatments of prometryne at 2 lb, linuron at 1 lb, C3126 at 1.5 lb, UC22463 at 8 lb, dinoseb emulsifiable concentrate at 2 lb + monolinuron at 1 lb, and C6989 at 2 lb + C3126 at 1 lb all gave almost complete control of both broad-leaved weeds and grasses, and did not injure the crop.

Carrots—Linuron at 1 and 2 lb as preemergence applications gave complete control of broad-leaved weeds and grasses, but the 2-lb rate tended to reduce yield. Chloroxuron at 4 lb gave good initial weed control. In general, postemergence treatments gave best results applied when carrots and weeds were small. None of the postemergence treatments gave satisfactory grass control.

Cole crops—Considerable work was done to find suitable herbicides for direct-seeded cole crops. In a cooperative trial with the Research Station at Vancouver, the effect of two soil insecticides, thionazin and fensulfothion, applied for root maggot control was studied when accompanied by herbicide treatments. There was some evidence of increased phytotoxicity with certain herbicide–insecticide combinations. This will be explored further in subsequent seasons.

Potatoes—A preplanting treatment of EPTC at 6 lb incorporated by rotovator gave excellent grass control, but not complete control of broad-leaved weeds. Of the treatments applied before crop emergence, only linuron at 2 lb or a mixture of paraquat at 0.5 lb and linuron at 0.75 lb gave effective control of grasses and broad-leaved weeds. Paraquat at 0.5 lb gave satisfactory weed control when applied after crop emergence and when weeds were established.

Sweet corn—Preplanting treatments with EPTC at 4 and 6 lb gave superior control of grass and slightly inferior control of broad-leaved weeds to that obtained with

atrazine at 4 lb. When applied after planting, but before emergence of the crop and weeds, the following gave complete control of broad-leaved weeds and almost complete control of grasses: linuron at 1.5 lb, Linazine at 3.5 lb, linuron at 1 lb + dalapon at 8 lb, and WL9385 at 2 lb. Atrazine at 1.5 lb and SD11831 at 0.13 lb + atrazine at 1.5 lb failed to control large crabgrass, *Digitaria sanguinalis* (L.) Scop. In a postemergence test of atrazine alone with several types of oils, the addition of oil apparently increased the effectiveness of a given rate of atrazine against broad-leaved weeds without affecting corn yield, but no treatment effectively controlled large crabgrass or barnyardgrass, *Echinochloa crusgalli* (L.) Beauv. In another postemergence test the overall application of WL9385 at 4 lb was promising, and directed sprays of Cypromid at 2 lb or paraquat at 0.5 lb gave excellent control of all weeds, but linuron gave only partial control of grasses.

SMALL FRUITS

Strawberry Breeding

16, 18

Rapid progress has been made toward the development of strawberry varieties resistant to several strains of *Phytophthora fragaria* Hickman, the organism that causes red stele. In 1967, two selections from crosses made in 1961 were placed in commercial growers' trials in the Fraser Valley. Seven selections from crosses made in 1962 have been propagated and they will be placed in growers' trials in 1968. Selections from crosses made in 1963 to 1965 have been screened for disease resistance and a number were planted in preliminary yield trials during the past year. The remainder will go into yield trials in 1968.

Herbicides for Strawberries

25

New plantations—Experimental treatments for new plantations of strawberries were repeated in 1967 and yields were taken from the plantings treated the previous year. The results from the 2 years showed that the most promising preplant treatment was a mixture of diphenamid at 4 lb and simazine at 0.5 lb/acre incorporated in the top 2 or 3 inches of soil by means of a rotovator. When diphenamid was used alone, at least 6 lb was necessary for adequate weed control. Yields were recorded from plots treated in 1966 with diphenamid alone, and mixtures of diphenamid and simazine, diphenamid and 2,4-DEP, and simazine and charcoal. Although all diphenamid treatments, alone and in mixtures, caused varying degrees of injury to the plants, yield of berries was not affected.

Established plantations—The herbicides chloroxuron and simazine were applied singly and in combination at various times during the year (spring, late summer, and fall) to plants established in 1965. Atlox 209 emulsifier at 4 lb/acre was tested as an additive to chloroxuron and the chloroxuron–simazine mixture.

All treatments applied in the spring gave excellent weed control, all plots being practically weed-free through to picking. Applying the chloroxuron–simazine mixture in July and again in October depressed strawberry yields. The addition of Atlox to the mixture further decreased yield. Atlox plus chloroxuron caused some marginal leaf chlorosis to strawberries, whereas Atlox plus chloroxuron plus simazine caused considerable chlorosis and necrosis and decreased the production of runners.

Control of Gray Mold and Powdery Mildew in Strawberries and Raspberries

7

Fungicide 1991, a systemic fungicide, showed considerable promise for the control of gray mold, *Botrytis cinerea* Pers., and powdery mildew, *Sphaerotheca macularis* (Wallr. ex Fr.) Magn. Berry infection by both fungi was practically eliminated in Stelemaster strawberries when the fungicide was applied at 0.25 lb/acre. Fungicide 1991 proved to be as

effective as captan, dichlofluanid, and DAC2787 for control of preharvest fruit rot in Willamette raspberries and was more effective for postharvest rot control. Dichlofluanid reduced berry size, whereas captan, DAC2787, and Fungicide 1991 all tended to increase berry size. Fungicide 1991 was as effective as dinocap and slightly better than sulfur for the control of powdery mildew on the leaves of Northwest strawberries. Repeated applications of Fungicide 1991 at intervals of 14 days were required to control powdery mildew when the disease was active.

Raspberry Breeding

3, 17, 19

The objectives of the raspberry-breeding program are to develop high-yielding, winter-hardy, disease-resistant varieties that are suitable for processing. In an attempt to meet these objectives more than 10,000 seedlings have been produced since 1959.

The selection 59-03-86 (Malling Promise × Creston) was placed on trial with commercial growers. This selection showed particular promise for mechanical harvest because of ease of picking, upright nonspreading plant habit, and uniform ripening of fruit. Selection 59-03-86 is immune to aphids and resistant to powdery mildew. Several selections from crosses made in 1961 to 1964 were increased for advanced testing. Increased emphasis is being given to selecting for adaptability to mechanical harvest, ability to produce commercial yield in the first year after planting, and resistance to fruit rot.

Pollination Techniques for Red Raspberry

Fairview and Newburgh flower buds pollinated with Willamette pollen had more fruits and more drupelets per fruit, and consequently more seeds, if emasculated when wider than 6.5 mm. Buds of Fairview wider than 8.5 mm and those of Newburgh wider than 7.2 mm showed some drupelet development without pollen application, indicating that self-pollination had occurred.

Willamette flower buds pollinated with Newburgh pollen had more fruits and more drupelets per fruit when pollinated 2 days after than when pollinated at time of emasculation or 4 days after emasculation.

Tomato Ringspot Virus in Raspberries

8

The effects of tomato ringspot virus (TomRSV) on plant and fruit development of raspberries vary considerably, depending on the variety. Infected plants of the variety Fairview were severely injured in the first 2 years of the plantation. Plant vigor and fruit yield were greatly reduced. In the 3rd year there was a rapid decline of the plants, characterized by 10 to 80% of fruiting canes being partly or completely killed and leaves on the new cane growth of infected plants showing epinasty and early abcission. It is suggested that what was often considered to be winter injury may have been caused by infection with TomRSV. Infection in Newburgh, Sumner, and Willamette raspberries had little or no effect on plant and fruit development.

ANIMAL SCIENCE

Influence of Stage of Harvest on Nutritive Value of Sweet Corn

Pioneer 383 corn was harvested at eight weekly intervals, beginning 1 week after silking, thus providing for a succession of maturity stages ranging from incipient cob development to a hard dough stage of kernel.

Yields of dry matter increased with successive stages of maturity. Total water-soluble carbohydrates in the stalk were highest 2 weeks after silking, whereas the levels in the leaf fluctuated widely between harvests. Total N content declined steadily with advancing maturity. Results from digestion trials with sheep indicated that nutritional value and yield of digestible nutrients did not differ significantly in the last three harvests (early dough to hard dough). Earlier harvests showed a higher content of digestible crude protein, but intake and yields of digestible dry matter were lower.

Estimating the Fat and Lean Composition of Bovine Ribcuts

5

The relative merits of four physical methods of estimating chemical rib fat have been evaluated by regression analysis. The methods in order of decreasing precision were: physical separation, planimeter area, specific gravity, and millimeters of rib fat. It was also found that *longissimus dorsi* cross-sectioned area was positively correlated with separable rib lean at constant carcass weight. When carcass weight was not held constant, however, this correlation was negative. Scribing the carcass chine resulted in a decrease in total fat area and an increase in rib fat depth, but the *longissimus dorsi* region was unaffected.

POULTRY

Force Molting of Laying Birds

Five rations were tested for three resting periods of 10, 20, and 30 days on birds that had completed the 1st year of lay. The experimental drug I.C.I.33828 was added to four rations ranging in protein content from 12 to 16%, fed to appetite. The fifth ration, comprising wheat and oats fed at 5 lb per 100 birds, served as a control.

After returning to production the birds rested for 30 days started to lay at a faster rate than those rested for 20 days. However, total production was about the same for both. Laying-house mortality was highest for the birds fed the highest protein ration and rested for 10 days. In general, egg production seemed to be unaffected by the level of protein fed during the resting period. Fertility and hatchability of eggs were not reduced by administration of the experimental drug during the resting period.

Experimental Control of Onset of Lay

The experimental drug I.C.I.33828 has been used during the past 2 years in an attempt to regulate the onset of lay in pullets. Pullets given the experimental drug from 16 to 26 weeks of age were kept out of lay while the untreated controls started to lay quite heavily. After removal of the drug, the treated pullets came into lay quickly and peaked at 88% production within 1 month. Those pullets allowed to come into lay without treatment laid 5% more eggs during the laying year. However, the treated birds that had been kept out of lay to 26 weeks of age produced more large and extra large eggs. Reproductive disorders were not increased in the group receiving the experimental drug. Quality and hatchability of eggs were not significantly different for the two groups.

The experimental drug I.C.I.33828 is not presently registered in Canada for commercial use in poultry flocks.

TRADE NAMES AND MANUFACTURERS OF PESTICIDES AND OTHER DRUGS

Coded number	*Manufacturer*
Alar	UniRoyal Ltd.
Atlox 109	Green Cross Products
C3126	CIBA Company Ltd.
C6989	CIBA Company Ltd.
Cycocel	American Cyanamid Company
Cypromid	Chemical Dept., Gulf Oil Corp.
DAC2787	Diamond Alkali Co.
EPTC	Stauffer Chemical Co.
Fungicide 1911	E. I. DuPont de Nemours & Co. (Inc.)
Linazine	Niagara Chemical Division, FMC
Phosphon	Virginia–Carolina Chemical Corporation
SD11831	Shell Canada Ltd.
TIBA	International Minerals Corporation
2,4-DEP	Amchem Products Inc.
UC22463	Union Carbide Corporation
WL9385	Shell Canada Ltd.

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Research Station
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PROFESSIONAL STAFF

R. H. Handford, B.S.A., M.Sc., Ph.D.	Director
W. B. G. Holliday	Administrative Officer

Veterinary–Medical Entomology Section

J. D. Gregson, B.A., M.Sc.	Head of Section Ticks
L. C. Curtis, B.A.	Biting flies
G. B. Rich, B.A.	Toxicology
P. R. Wilkinson, B.S., M.A.	Ticks

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D. A. Arnott, B.Sc.	Forage crop pests

Range Ecology Section

A. McLean, B.S.A., M.Sc.	Head of Section Range ecology
S. Freyman, B.Sc., M.S.A., Ph.D.	Range ecology

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W. A. Hubbard, B.S.A., M.Sc.	Hay; silage; feed grains

Soil Section

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Departure

W. L. Pringle, B.S.A., M.S.F.	Range improvement

Transferred to Research Station, Beaverlodge, Alta., January 1967

INTRODUCTION

The Research Station, Kamloops, B.C., is concerned mainly with the problems of the ranching industry. In 1967 the Entomology Section of the Station did research on the ecology, physiology, and control of several species of ticks, cattle grubs, mosquitoes, black flies, grasshoppers, and pests of grass seed crops. The Range section continued its research on the management of cattle and vegetation on both natural and reseeded ranges, the testing of species and varieties for the production of winter feed, the management of irrigated pastures, the improvement of organic meadows, and the classification of alpine soils. As in other years, many of the experiments were set up on the ranches themselves with excellent cooperation from the ranchers.

R. H. Handford
Director

PINEGRASS

Further concentrated research on pinegrass, *Calamagrostis rubescens* Buckl., confirmed previous results and provided additional information on this important forage component of the forested rangelands of British Columbia.

Pinegrass clipped August 25 from plots that had been clipped before June 30 had a considerably higher protein content than samples taken August 25 from plots not previously clipped. Thus the total protein yield is greater when pinegrass is harvested twice than when it is harvested only once.

N applied to plots in the spring of 1966 at 150 lb/acre had a significant effect on the 1967 as well as the 1966 yields and palatability of pinegrass. However, in 1967 the protein content was no higher in the grass from the fertilized plots, although it had been higher in 1966.

Chemical analyses gave further indications of probable reasons why rate of gain of cattle decreases in late summer or early autumn on pinegrass ranges. The crude protein content decreased throughout the season, whereas lignin, crude fiber, and total ash increased. Ca increased and P decreased progressively, but the levels were adequate, as was the Ca:P ratio. Mn and Fe remained adequate, but Zn was rather low and Cu probably inadequate. The silica content was surprisingly high, rising to 10% by October.

Digestibility values, determined at the Research Station, Summerland, B.C., courtesy of Dr. J. E. Miltimore, dropped from 65% at the beginning of June to 57% at the beginning of July, 55% at the beginning of August, 48% by mid-September, and less than 40% by October.

RELATIONSHIP OF HEIGHT TO WEIGHT IN BLUEBUNCH WHEATGRASS

Studies have shown that 56% of the weight of plants of bluebunch wheatgrass, *Agropyron spicatum* (Pursh) Scribn. & Smith, is above 6 inches from the ground and 75% above 4 inches. It would be necessary, then, to stop grazing this species at a height of at least 6 inches if the recommended 50% retention of vegetation is to be approximated.

THE USE OF FERTILIZERS ON ORGANIC SOILS

Limited investigations in previous years have not indicated that there are any S deficiencies in organic soils in British Columbia; yields of native sedges were used as criteria. In experiments in 1967, however, a stand of reed canarygrass and Alsike clover, seeded on newly broken sedge peat, responded markedly; yields from plots receiving N, P, K, and gypsum were about 10 times those from plots receiving only N, P, and K. P appeared to be essential to the establishment of even a nominal stand, with further increases in yield where N was included with P, especially the higher rates of P. In another trial, on a stand of native sedge and grass in the same meadow, plots receiving flowers of S together with N, P, and K yielded only 20% more than those to which S was not applied. Indications are that the native vegetation either requires less S or is better able to extract it from the soil; cultivation may also have been a factor in the 1967 results, or there may be greater differences between or within meadows than was previously thought. Experiments will be expanded to obtain more information on the relative importance of the various factors and on the practicability of applications of S.

In another meadow, significantly higher yields of sedge were still being obtained from plots that received P in 1960 or 1961 than were obtained from unfertilized plots; there appeared to be no effect remaining from N and very little from K. Reapplication of N in the fall of 1966 to split plots that had previously received P, or P and K, produced marked increases in sedge yields in 1967.

HAY, SILAGE, AND FEED GRAIN

Variety and management trials were conducted in the Station's irrigated plots on corn, barley, wheat, sorghum, sorghum – Sudan grass, alfalfa, orchardgrass, reed canarygrass, timothy, white clover, trefoil, and bromegrass; crested wheatgrass and Russian wild ryegrass were tested under dryland conditions. Further testing will be necessary before any of the existing recommendations may be changed.

An interesting and unexpected sidelight of an alfalfa trial seeded in 1966 was the appearance in 1967 of typical symptoms of K deficiency in the variety Lahontan. Tissue samples averaged 1.36% K in Lahontan, 1.93% in Vernal, and 1.95% in Columbia 67. The yield of Lahontan in this trial was significantly lower than yields of any of the other five varieties.

PERFORMANCE OF CALVES ON PASTURE IN RELATION TO LEVELS OF FEEDING IN THE PRECEDING WINTER

There appeared to be a small net economic advantage in wintering Hereford steer calves to gain an average of 1.44 lb per day as compared with 1.09, 0.63, or 0.36 lb, and grazing them through the following summers on irrigated pastures. The average sale price per rail-graded carcass at the end of the grazing period, less cost of winter feed, was $170.34, 165.58, 164.59, and 157.86 respectively. Labor costs for handling the winter feed were not calculated, but they would be proportional to the quantity of feed consumed by each group. The lowest-gaining group consumed slightly less feed during the summer as well as the winter.

As would be expected, part of the apparent advantage of the higher-gaining groups lay in slightly better grades. Of the group that gained 1.44 lb per day during the winter, 34 graded choice and

good, of the next group 25, the next 21, and the lowest only 12.

During the winter the top-gaining group consumed an average of 14.69 lb of dry matter per day and required 10.23 lb of feed per pound of gain. The figures for the others, in descending order of winter gain, were: 12.51, 11.60; 9.54, 15.10; and 7.93, 22.37. During the summer, however, compensatory gains were evident; the group on high winter rations averaged 1.82 lb per day, the next 2.06, the next 2.26, and the lowest 2.35. The pounds of dry matter per pound of gain, determined in the groups on zero grazing, averaged 10.95, 9.48, 8.77, and 8.07 respectively.

FACE FLY INVASION

Systematic surveys in 1967 indicated that the face fly, *Musca autumnalis* De Geer, was infesting cattle in most, possibly all, of the cattle-grazing areas of British Columbia south of the 52nd parallel of latitude; it was not recorded for the province until 1966, and then only in southeastern areas. The hot, unusually dry summer may have been a factor in the seemingly rapid spread and high incidence.

It is doubtful that the species was a factor of any importance in the concurrent incidence of pinkeye; the disease was severe in the Williams Lake district, where no face flies have yet been found.

PHYSIOLOGY, ECOLOGY, AND CONTROL OF TICKS

Chemical control—Studies showed that more reliable data are obtained and considerable economy is achieved by doing acaricidal experiments in pastures infested with ticks by the "rodentaria" method than in naturally infested pastures. The currently recommended spray of 0.25% BHC was superior to one of 0.5% carbaryl and one of 1.5% DDT in controlling the Rocky Mountain wood tick. The acaricides were applied to the topline of yearling cattle, from the poll to the lumbar region, at 0.5 gal per animal.

Resistance to tick feeding—Cattle repeatedly infested by the Rocky Mountain wood tick develop a skin reaction that inhibits tick feeding. This has been observed in yearling animals in naturally infested pastures as well as in pastures infested through the medium of our outdoor "rodentaria." In 1967, reaction became apparent within 10 days of the initial exposure to the ticks and marked in 15 days. Cattle are favorable hosts and definitely subject to paralysis when first attacked by ticks.

Electric method of charting feeding patterns (8)—An electric method of charting feeding patterns in aphids and mosquitoes has been found useful in studying the functioning of the feeding apparatus of the Rocky Mountain wood tick. The method consists of passing a weak electric current through the host and the tick and amplifying it by means of an oscilloscope. The various feeding patterns obtained are compared with the activities of ticks feeding on hamster cheek pouches.

Diapause—Ticks reared to the adult stage in the laboratory appear to have much less desire to feed than do ticks that develop in nature. Adults of the Rocky Mountain wood tick in nature and in "rodentaria" emerge from the nymphal skins from July until fall. They have been observed to wander on the soil surface and on vegetation in September and October, but they do not quest for hosts until the next spring. Ticks cultured at 25 C usually do not engorge fully and when they do so require 10 days instead of the 7 required by wild ticks. Investigations

are continuing in an attempt to define the stimuli that terminate diapause in nature and to simulate them in the laboratory.

A possible 3-year life cycle—The discovery that the Rocky Mountain wood tick can complete its life cycle in 1 year as well as the normal 2 was made previously. More recent observations indicate a probable 3-year cycle under short-season conditions at high altitudes. In the Kamloops district, larvae of the 1-year or 2-year cycle usually hatch by July and feed or die before winter. At an altitude close to 7,000 ft in the Banff, Alta., district, larvae were taken from a Columbian ground squirrel on June 16, 1967, and an ovipositing female was found on September 13, 1966. Tests in 1966–67 proved that larvae could survive winter conditions with minimal protection at ground level at about 1,130 ft and also at 5,880 ft.

Studies of paralysis—Sheep were paralyzed in 1967 by Rocky Mountain wood ticks that completed their life cycles in 1 year. This had not been attempted experimentally previously.

Rocky Mountain wood ticks were observed on mule deer and moose in the Kamloops Wildlife Park in 1967, and they appeared to be engorging successfully. The paralysis of a captive mule deer fawn was reported earlier.

Tests made in 1967 suggest that the toxin responsible for paralysis by the Rocky Mountain wood tick is probably not the same as that produced by *Ixodes holocyclus* Neumann, the tick that causes paralysis in Australia. Using the Australian method, with the assistance of facilities and personnel of the Royal Inland Hospital, Kamloops, prefed Rocky Mountain wood ticks were extracted and fractionated, and the fraction injected into mice and marmots. Neither rodent species was affected visibly in 21 tests in which doses ranged up to 20 times the dose lethal to dogs in Australian experiments with *I. holocyclus*.

CONTROL OF CATTLE GRUBS

Pour-on systemic insecticides containing 2% and 3% fenthion gave higher grub reductions from applications on October 27 and December 19, 1966, than from an application on September 20; however, only the reductions of 94.6% and 97.2% from the two later applications of the 3% material were great enough to be considered satisfactory. Fenthion administered in drinking water at 1.6 mg/kg of animal weight on each of 6 consecutive days also gave a satisfactory reduction, 90.1%.

A pour-on of 8% trichlorfon gave excellent reductions from applications made October 27 and December 19, but that from an application on September 20 was only 88%. Ruelene 25E,[1] diluted 1:3 with water, also gave excellent results from applications on November 22 and December 19, but only fair results from applications on September 20 and October 27. Ruelene 8R gave good to excellent reductions from all three dates on which it was applied: October 27, November 22, and December 19.

CONTROL OF MOSQUITOES

Abate,[2] 2% granular at 0.1 lb/acre, was effective in controlling larval mosquitoes in rangeland snowpools; 0.05 lb/acre was less satisfactory. The larvae were mainly of the species *Aedes cataphylla* Dyar and *A. fitchii* (Felt & Young).

[1] Dow Chemical Company.
[2] Cyanamid of Canada Limited.

CONTROL OF BLACK FLIES

Abate applied at 1.2 parts per 10^7 of water for 15 min was effective in controlling black flies, mostly *Simulium canadense* Hearle, in a creek near Kamloops in 1967. Control, determined from plaques planted in the creek beforehand, was complete at check points 0.96, 1.08, and 1.2 miles downstream from the point of application. Check points were not established beyond this distance. At points 0.48, 0.6, and 0.72 mile downstream the survival of larvae was less than 1%, increasing to 7.1% at 0.12 mile.

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R. G. Atkinson, B.S.A., Ph.D.	Diseases of ornamentals
J. H. Crossley, B.S.A., M.S.A.	Ornamental crops
E. F. Maas, B.S.A., M.Sc.	Soils and plant nutrition
W. R. Orchard, B.A., M.S.	Nematodes
N. V. Tonks, B.S.A., M.S.	Insects of ornamentals
R. H. Turley, B.S.A.	Forages, cereals, and turf grasses
K. W. Chong, B.S.A. (Production and Marketing Branch)	Supervisor, Post Entry Quarantine Station located at the Research Station, Saanichton

INTRODUCTION

This report is a summary of research for the year 1967. None of the research is described in detail as technical accounts of completed research have been or will be published in scientific journals. If an experiment is still active, progress is outlined.

The summer of 1967 was one of the driest on record. There were 83 more hours of sunshine during June to August than the 54-year average. No rain at all fell in August, and less than an inch fell between June 1 and August 30; the 54-year average is 2.71 inches. Because of expanded irrigation at the Research Station, crops were not affected, but farms in the area suffered from lack of moisture during the growing season.

The Post Entry Quarantine Station continued to expand under the supervision of Mr. K. W. Chong. Three additional screenhouses are being built to provide maximum isolation of virus-free stock.

H. Andison
Director

SOIL SCIENCE

Crop Fertilization

Response of forage to fertilizer on a peat soil—A 4-year fertilizer experiment with a silage crop of orchardgrass, perennial ryegrass, and Ladino clover on a sedge–peat soil shows an economical response to N, P, and K, but not to Ca or Mg. The most suitable rate of N was 60 lb/acre applied on April 1 and 30-lb applications after the first and second cuts.

The omission of P from the fertilizer mixture resulted in progressively lower yields each year, and by the 4th year a 45% reduction was recorded. The inclusion of P at 40 lb of P_2O_5 per acre per year maintained the production level at 10,000 lb of dry matter per acre. Plots receiving an application of 80 lb of potash (K_2O) per acre outyielded plots that received 40 lb per acre by 1,500 lb of dry matter per acre, and an increase to 120 lb of potash increased the yield by a further 500 lb. No response was obtained from either ground limestone or magnesium sulfate where the pH of the soil was 5.0 and the exchangeable Ca was 50% of the total cation-exchange capacity.

PLANT SCIENCE

Cucumbers

Soilless culture of greenhouse cucumbers—Greenhouse cucumbers were grown successfully in beds of sawdust, or a 3:1 sand–sawdust mix, and yields of up to 50 marketable cucumbers per plant were realized during the period March 21 to July 7. Burpee Hybrid was the most productive variety tested. A nitrogen level of 210 ppm in the nutrient solution was apparently too high for most of the fruit produced to be of medium size.

Grapes

Evaluation of early grape varieties—Eight early varieties were old enough to produce fruit for the second season in 1967. Temperatures for the growing season were above average with 1,847 heat units in day-degrees above 50 F. Fruit of the following varieties grown by the Kniffin system and harvested from September 19 to October 17 rated as follows in percentage of soluble solids and total tartaric acid (g/100 ml): Foch 21, Aurora 21 (1.10), New York Muscat 19 (0.95), Diamond 17 (0.63), Portland 17 (0.36), Himrod 17 (0.54), Seibel 9549 16 (1.32), Patricia 15.

Robins and starlings removed almost all the fruit of Foch, a small-berried blue variety. Birds damaged Seibel 9549 slightly, but the other varieties were not seriously affected.

Lawns

Evaluation of lawn quality—Turf quality is usually measured by visual ratings or by dry-matter yields. Neither method is entirely satisfactory. Visual ratings vary with individuals, and high dry-matter yields are not necessarily an indication of an ideal turf. A number of agronomic characteristics were studied to determine if a chemical or mechanical method could be devised to positively rate turf quality. A reasonably close correlation was obtained between dry-matter yield and visual ratings, indicating that dry-matter yield is a good practical method of evaluating turf quality. Chlorophyll content and sod density counts gave good correlation with dry-matter yields and visual quality ratings. These characteristics are a reliable index of turf quality.

Correlation coefficients based on agronomic characteristics for measuring quality of turf are as follows:

Items correlated	*Correlation coefficient (r)*
Visual rating × dry-matter yield	0.84*
Chlorophyll × dry-matter yield	0.73*
Sod density × dry-matter yield	0.69*
Chlorophyll × visual rating	0.82*
Sod density × visual rating	0.82*

*Significant at $P = 0.05$.

Fertilizers for lawns—A factorial experiment is in progress to study the effect of four sources, rates, and frequencies of applications of N fertilizer on lawn quality. The 30- and 100-lb/acre rates were not sufficient to maintain vigorous growth, and as a result turf quality was lower than on the 200- and 400-lb rates. The 400-lb rate maintained more uniform growth of higher quality than the other rates.

The frequency of fertilizer applications affected turf quality. Single and double applications produced periods of high and low quality, but three applications were sufficient to maintain uniform growth over the entire season.

Nitrogen from different sources (ammonium nitrate, urea-coated urea, and urea formaldehyde) were similar in effect.

Ornamentals

Residual effects of growth retardants on rhododendrons—When 1st-year container-grown rhododendrons were treated with growth retardants in 1967 and forced in a 63 F greenhouse, they flowered up to 10 days later than untreated ones, the blooms averaged 0.2 inch less in diameter, and the flowers in two cultivars showed some crimping, although results generally indicated good forcing possibilities.

Residual studies also showed that plants in phosfon-drenched soil were only half as high as and about equal in spread to untreated specimens 3 years after application of the retardant and after two transplantings into untreated soil. The difficulty of removing the phosfon-bearing soil from the densely fibrous root mass without impairing rhododendron transplants accounts for the persistent "dwarfing" effect. Blooming capacity based on the number of flower buds was greater in phosfon-treated plants in the 1st and 2nd year after treatment. In the 3rd year there was no significant difference in the number of flower buds, indicating that the flowering capacity of treated and untreated specimens was the same. Propagation of rhododendrons by cuttings 1 year after a single soil drench of phosfon (concentrations 0, 0.1, 0.2, 0.3, 0.4, and 0.6 g per 7-inch azalea pot) showed no significant effect on percentages of rooted cuttings or the amount of rooting.

Potatoes

Blackening of Netted Gem potatoes caused by bruising—A 20-lb sample of Netted Gem potatoes from each of six growers was separated into three groups according to their resistance to bruising. Group 1 showed considerable blackening from artificial bruising; group 2, a moderate amount and group 3, the least. The potatoes in group 2 were discarded; groups 1 and 3 were propagated for 3 years. Each year the tubers were artificially bruised; in group 1, those showing the most blackening were used for seed, and in group 3, those showing the least were used. A rating of 0 represented no blackening and a rating of 6 represented severe blackening. In the first generation the average rating for the six grower samples was the same (1.4) for both groups 1 and 3. In the second generation, the average rating was 3.8 for group 1 and a significantly lower rating of 3.0 for group 3. In the third generation the average rating was 3.2 for group 1 and 2.0 for group 3, again a significant difference. In a mixed population of potato tubers, it appears that a significant increase in resistance to blackening caused by bruising can be obtained by selection.

Effect of seed stock maturity and storage temperatures on tuber initiation of Netted Gem potatoes—Two years of experimental data showed that breaking the dormancy of Netted Gem seed potatoes by raising the storage temperature 3 weeks before planting had no effect on the yield. However, the maturity at which the seed stocks were harvested affected the yield of the subsequent crop. Seed from a combination of early planting and late harvesting reduced the yield by 2,600 lb on an 18-ton/acre crop. Seed from other combinations, such as early planting – early harvesting, late planting – early harvesting, and late planting – late harvesting did not influence the yield.

Weed Control

Effects of 2,4-D and Ioxynil on seedling lawn grasses—In a growth-room experiment, 2,4-D applied at 1 lb/acre seriously injured Park bluegrass and at 3 lb/acre

killed it. There was little difference whether the treatment was applied just after emergence, or delayed until the seedlings reached a height of 2.5 inches and were then clipped to 1 inch. Chewings fescue was intermediate in its reaction, whereas Highland bent initially suffered moderate and severe injury at 1 and 3 lb/acre respectively, but outgrew this setback. These results were unsuspected, as bluegrass is generally considered resistant to 2,4-D. Ioxynil[1] at 0.5 and 1 lb/acre did not adversely affect any of the three grasses at either stage of maturity.

Control of weeds in seedling lawns with Ioxynil and 2,4-D—Excellent weed control without injury was obtained by applying Ioxynil at 1 lb/acre to newly emerged fescue, bentgrass, and bluegrass. A rate of 3 lb of 2,4-D per acre applied at the same time was required for comparable control of weeds. Although this rate stunted growth of these grasses, there was little evidence of thinning out of the stands, and there was fairly good recovery. When herbicide applications were delayed until after the first mowing, there was excellent weed control and the grasses were much more tolerant to 2,4-D at the 3-lb rate. But Ioxynil did not control weeds as well at this time as it did when applied earlier.

Chemical weed control in lettuce—In weedy organic soils, best control was obtained by preparing the land 10 days before seeding, that is, by making a "stale" seedbed; then, 3 to 4 days after seeding, applying a mixture of CDEC[2] and chlorpropham each at 2 lb/acre, with the addition of diquat or paraquat, if grassy weeds are present, at 0.5 lb/acre to kill emerged weeds. This treatment has given the crop a good start without weed competition for 2 to 3 weeks in even the weediest soils. In less weedy mineral soils, the stale-seedbed method was less beneficial; good control of early weeds was obtained by the CDEC-chlorpropham mixture applied 3 to 4 days after seeding into a freshly prepared seedbed.

Effect of the herbicides trifluralin and diphenamid on petunia and phlox transplants—In previous studies, trifluralin applied as a preplant soil-incorporated treatment at 1 to 2 lb/acre provided good weed control and did not adversely affect 13 of 15 species of annual flowers treated. The two species that were injured, *Petunia hybrida* Vilm. and *Phlox nana compacta* Nutt., were retested in 1967, and the adverse effect of trifluralin was confirmed. Also confirmed was the resistance of petunia to a preplant-incorporated application of diphenamid at 4 to 8 lb/acre. Phlox showed some sensitivity to this chemical but less than to trifluralin.

PLANT PATHOLOGY AND ENTOMOLOGY

Diseases

Control of Phytophthora *and* Pythium *species*—Fungicides active against *Phytophthora* and *Pythium* species have been evaluated in a growth room and outdoor microplots (3 by 6 ft) to determine effective concentrations applicable not only on fallow soil but also around living host plants. Rooted cuttings of *Chamaecyparis lawsoniana* (A. Murr.) Parl. var. *ellwoodii* were grown in 6-inch pots of four types of steam-pasteurized nursery soils in the growth room, and in soil fumigated with methyl bromide in the microplots. The soils had been artificially infested with cultures of *Phytophthora lateralis* Milbr. & Tucker before planting. The most promising materials to date are nabam and Dithane M-45[3] wettable powder. Both materials at 4,000 ppm (about equivalent to nabam at 1 gal in 50 gal and to Dithane M-45 at 2.5 lb in 50 gal) gave little or no control as a

[1] Amchem Products Inc.
[2] Monsanto (Canada) Ltd.
[3] Rohm and Haas Company.

single preplant drench, but gave partial control, with delay in onset of symptoms, when a second postplant drench was immediately applied. These two chemicals will be evaluated further to determine whether or not higher, more effective concentrations may be used around living plants.

Nematodes

Nematodes in tree fruits—All trees at the Summerland nematode tree-fruit experimental site were sampled for nematodes in 1967. Growth measurements were recorded for trees grown in soil artificially infested with *Pratylenchus penetrans* (Cobb) Filipjev & Stekh. and *Paratylenchus* sp. at planting and for noninoculated control trees growing in the same orchard. Fruit yields for most tree types were recorded. Analyses of data are not yet complete. Nematode data confirm results reported for 1966. Total individual tree populations of *P. penetrans* continue to increase in inoculated trees, but per-unit volume has not increased significantly. Within the orchard, tree-to-tree spread of this nematode continues to be extremely slow, even when inoculated and control trees are adjacent in the orchard. Apparently *Paratylenchus* sp. is not as well adapted to the site conditions as *P. penetrans.* Per-tree recovery of *Xiphinema americanum* Cobb continues to increase. To date, growth data show no significant difference between trees of the same types grown in infested soil and control trees.

Nematodes in forest nurseries—In 1966 the plant parasitic nematodes *P. penetrans* and *X. bakeri* Williams were reported to be present in British Columbia forest nurseries and were associated with the corky root disease of Douglas-fir seedlings. At the Canada Forest Research Laboratory, Victoria, B.C., work in 1967 indicated that *X. bakeri,* a rather large nematode that has a long and robust stylet, acts as a principal synergist in the disease complex. It makes punctures on the roots when feeding, and the punctures are utilized by the fungus *Cylindrocarpon radicicola* Wr. as infection courts. After entering the roots, the fungus develops to bring about the diseased condition.

Insects

Combined treatments for nematode and bulb fly control on narcissus—In-furrow fall applications of granular Dasanit[4] at 5.6 kg of toxicant per hectare reduced infections of *Ditylenchus dipsaci* (Kühn) Filip. in King Alfred narcissus the subsequent spring by 50%. Phorate at 3.36 kg, disulfoton at 2.24 kg, and Zinophos[5] at 5.6 kg also reduced infection significantly. Dyfonate[6] at 2.8 kg and Nemacide[7] at 11.2 kg were less effective. All materials gave good control of *Merodon equestris* Fabricius, and there was no evidence of phytotoxicity.

A flea beetle attacking Canada thistle—During October 1965, 75 adults of a flea beetle, *Altica carduorum* (Guer.), were caged at Saanichton as part of a study conducted by the Research Institute at Belleville on the ecology of insects attacking Canada thistle. No increase in the number of beetles occurred during 1966. Only 12 emerged in the spring of 1967, starting about April 6. The average growth of thistles at this time was 4 inches. Egg laying began on May 23, when thistles were 12 inches high, and reached a peak during mid-June to mid-July. A total of 2,224 eggs were counted on plants in the cage during the season. Average counts of eggs showed that 58% hatched, 22% did not hatch, and 20% were lost because of unknown causes.

The first larvae were seen on June 1, when thistles were 25 inches high and beginning to flower. Larvae were present from early June to mid-September; the greatest numbers occurred around mid-

[4] Chemagro Corporation.
[5] American Cyanamid Company.
[6] Stauffer Chemical Company.
[7] Virginia—Carolina Chemical Company.

August, when thistles were mature and seeding.

Current-season adults appeared in late July and laid eggs during August. A total of 101 beetles emerged during the season, 71 during August, 9 in September, 16 in October, and 5 in November. Most of those emerging later in the season developed from current-generation eggs.

Both adult and larval flea beetles fed on the thistle foliage causing extensive damage, but not before most of the plants had reached maturity.

Temperature, humidity, and precipitation records taken within the cage did not differ markedly from Station weather records for the season.

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Research Station
Summerland, British Columbia

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R. S. Downing, B.A., M.S.	Control of mites
R. D. McMullen, B.Sc., M.Sc., Ph.D.	Bionomics of pear psylla
C. V. G. Morgan, B.S.A., M.Sc.	Biology, ecology, and taxonomy of mites
M. D. Proverbs, B.Sc., M.Sc., Ph.D.	Control of codling moth by the sterility method
K. Williams	Chemistry of pesticides

[1] Appointed August 1967.
[2] Appointed November 1967.

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D. L. Ashby, B.S., M.S., Ph.D.	Plant nutrition
D. S. Stevenson, B.S.A., M.S., Ph.D.	Soil physics and irrigation

Plant Pathology Section

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A. J. Hansen, Dip. Agr., M.Sc., Ph.D.	Virus diseases of stone fruits and grapes
L. E. Lopatecki, B.A., B.S.A., M.S.A., Ph.D.	Parasitic tree fruit diseases
D. L. McIntosh, B.S.A., Ph.D.	Parasitic tree fruit diseases
S. M. Yang,[4] B.S.A., M.S.A., Ph.D.	Parasitic diseases of tree fruits and vegetables

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M. Meheriuk, B.Sc., B.Ed., M.Sc., Ph.D.	Postharvest physiology, biochemistry
S. W. Porritt, B.S.A., M.S., Ph.D.	Fruit harvesting and storage

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L. G. Denby, B.S.A., M.S.A., F.R.H.S.	Head of Section Breeding

Substation, Creston

F. M. Chapman, B.S.A.	Officer in charge Field crops

Departures

A. M. Swain Transferred to Personnel Administration Office, Calgary, Alta., August 1967	Administrative Officer

[3] On 18-month secondment to External Aid, Ghana, October 1967.
[4] Appointed October 1967.

B. B. Till, B.Sc., M.S., Ph.D. Resigned August 1967	Vegetable and tree fruit diseases
J. M. Wilks, B.Sc., Ph.D. Died November 1967	Pome fruit virus diseases; little cherry virus diseases

VISITING SCIENTISTS

T. Yakuwa, Ph.D. National Research Council postdoctorate fellow 1965–67	Postharvest physiology
N. Shanmuganathan, Ph.D. National Research Council postdoctorate fellow 1967–68	Fungus physiology of parasitism studies

INTRODUCTION

This, our fourth Research Report, summarizes the principal findings in 1967. Previously our reports were biennial or triennial, but they now will be annual. This is mostly a current progress report, although some completed research is presented. Detailed scientific and technical accounts are published in appropriate journals.

The numbers following subheadings in the text refer to the list of publications at the end of this report. Generally, reprints may be obtained from the authors.

It is with deep regret that I record the death after a short illness of Dr. Jack M. Wilks. Dr. Wilks served 19 years on the staff, first at the substation at Creston, working on the "little cherry" virus, and later at Summerland, where he made important contributions in the field of deciduous tree fruit virus diseases.

C. C. Strachan
Director

AGRICULTURAL ENGINEERING

Fruit Harvesting

Self-propelled orchard work platform—The machine, designed for use in hedgerow plantings of semidwarf trees, carries six pickers and two 25-bu bins. Platforms, hydraulically operated, telescope in and out of the main platform. A front-mounted forklift and a rear-mounted hydraulic hoist lift empty bins to the platform and deposit full bins on the ground. For maximum results from this machine, tree size and form must be rigidly controlled. In such plantings, the machine speeds up the picking and reduces manual labor.

Tomato Harvesting

35

Self-propelled tomato harvesting aid—The 1966 prototype was modified to carry six pickers instead of three, and lights were installed to permit harvesting at night. The picking rate is the same in artificial light as in daylight. It was found that the crop must be of reasonable uniformity and volume, and the fruit not less than a 3-oz size for the machine operation to be economical.

ANIMAL SCIENCE

Legume Bloat in Cattle

43

Bloat and 18-S protein content of alfalfa—In a 2-year study bloat did not occur when there was less than 1.5% 18-S protein in alfalfa. However, 50% of the cattle bloated when 18-S protein content was 5%.

18-S protein in the rumen—The concentration of 18-S protein in the rumens of cattle feeding on fresh alfalfa increased from zero to a maximum of 1 to 2 hr, then decreased to zero again in 5 to 7 hr. 18-S protein was not degraded in vitro by soluble enzymes in the rumen liquid or by microorganisms but only by the rumen protozoa. Suspensions of the particulate matter from ground protozoa were as effective in degrading 18-S protein as the living protozoa.

Heritability of 18-S protein in alfalfa—Fifty-five genotypes of alfalfa varied significantly in 18-S protein content from 3.4 to 6.0%. There was considerable variation between replications of individual genotypes. Twenty-seven percent of the variation observed was estimated to be genetic.

ENTOMOLOGY

Codling Moth

18, 27

Autocidal control—In 1966, sterile codling moths gave excellent control when released for the first time in a commercial apple orchard. In 1967, the release sites were reduced to five per acre (20% of the 1966 number), and the sterile moths to 450 per acre per week (25% of the 1966 number). By harvest, codling moths had injured only 0.09% of the apples. This was very good control in a year favorable for codling moth development.

European Fruit Scale

50, 51

Chemical control—Field and laboratory tests showed that the insecticides recommended for control of the San Jose scale, *Aspidiotus perniciosus* Comstock, would also control the European fruit scale, *Aspidiotus ostreaeformis* Curtis. Oil controlled both scales when applied at 4 gal/100 gal water during dormancy or up to the tight cluster bud stage. The addition of lime sulfur was not desirable because of its toxicity to plants and predacious mites. Summer sprays of parathion and diazinon, which are required for heavy infestations of San Jose scale, are not necessary for European fruit scale.

Pear Psylla

17, 19, 20

Chemical control—Several oils were evaluated for their control of pear psylla, *Psylla pyricola* Foerster, and their effect upon the trees. Based on the number of adults killed, Orchex 796 (viscosity 71.7) with 1.0% emulsifier and Volck Supreme oil (viscosity 147) gave the best control; PGSO-1 (viscosity 68.2) and PGSO-2 (viscosity 90) were intermediate; and Orchex 796 with 0.46% emulsifier and Orchex 696 (viscosity 58.5) were the least effective. All of the oils gave good control of pear psylla nymphs and European red mite, *Panonychus ulmi* (Koch). The oils also prevented leaf burn during hot weather in August. The oils caused enlargement and corkiness of the bark lenticels, but there was no effect on the quality of the pears.

Biology—During the extremely hot summer of 1967, adult pear psylla females were observed in a physiological state typical of adult diapause. Ovaries were undeveloped and fat bodies hypertrophied. Sufficient numbers entered this nonreproductive state to account in part for midsummer population declines observed in 1967.

Orchard Mites

3, 4

Chemical control—Summer applications of NC-5016 20% wettable powder at 2.5 or 3 lb/100 gal gave excellent control of the European red mite. Plictran 50% wettable powder, 4 oz; Galecron 50% emulsifiable concentrate, 0.75 pt; and Micasin 50% wettable powder, 1 lb, gave good control for 1 month after being applied on June 13. NC-5016 caused fruit and foliage injury to Rome Beauty, but not to Winesap, Jonathan, McIntosh, or Spartan apples.

Integrated control—Ten commercial apple orchards were selected for a study on integrated control of the European red mite and McDaniel mite, *Tetranychus mcdanieli* McG. Predacious phytoseiid mites were present during the dormant season in each of the orchards. A spray of dormant oil and ethion, oil alone, or Morestan was applied prebloom for European red mite control. In six orchards the phytoseiid mites reached a population density sufficient to control the phytophagous mites, so summer miticides were not necessary. In the other four orchards, phytoseiids did not increase and summer miticides were applied. Of the spray chemicals used, dicofol, binapacryl, and carbaryl were most toxic to the phytoseiids.

Tuber Flea Beetle

1

Chemical control—Soil-incorporated applications of Niagara 10242 10% granular broadcast after planting at 8 lb/acre or Dyfonate 10% granular at 4 lb/acre in two 16-inch bands, one after planting and a second in 6 weeks, gave 32–50% marketable potato tubers. The checks had 0% marketable tubers. Two band applications, each at 4 lb/acre of diazinon 5%, Temik 10%, or Niagara 10242 10% granular, made at the same times were significantly less effective. The postplanting broadcast or band treatments controlled first- but not second- or third-generation larvae. First-generation larval occurrence peaked 30 days after treatment; the second and third generation peaked 25 and 60 days after the second band treatments.

Biology—In the laboratory the tuber flea beetle, *Epitrix tuberis* Gentner, laid eggs singly in the soil near growing potato tubers and, to a lesser extent, near the crown of the root. In rearing cages, tubers stimulated oviposition 6.5 times. Females laid an average of 84 (21–170) eggs in 48 (18–74) days. At the peak of oviposition, they laid 5–18 eggs per day for 8–21 days. Viable eggs were laid up to 20 days after copulation. Some first-instar larvae entered growing tubers more than once and made several tunnels. They could not penetrate the thickened skin of a harvested tuber.

FRUIT AND VEGETABLE PROCESSING

Drum-dried Fruit Sauces

The laboratory double drum drier was modified by addition of pickup rolls, chilled air supply to cool the dry sheet, automatic feed hopper, and a steam exhaust system. These improvements allowed production of uniformly high-quality dried fruit sauce flakes on a continuous basis. Flakes made from applesauce containing 400 ppm sulfur dioxide had satisfactory color and flavor after 7 months' storage at 70 F, but showed significant darkening after 6 months' storage at 100 F. Blends of applesauce with strawberry, raspberry, cranberry, and blueberry purees also were drum dried successfully.

Continuous-roll Cooker for Canned Fruit

9

A large version of the continuous-roll cooker-cooler for 100-fl-oz cans was built by a local canner and operated through the season. Samples of cherries, apricots, peaches, fruit cocktail, and pears processed in the roll cooker were compared with the same material given a nonagitating process. The degree of syrup stratification was greatest in still-cooked cans. Because roll-cooked fruits were surrounded by stronger syrup during and immediately after processing, the drained weight was initially lower. For example, after 2

months' storage the drained weight of roll-cooked peaches was 0.42 lb lower. Differences between drained weights of roll- and still-cooked pears, cherries, and fruit cocktail were not significant after 4 months' storage. Roll-cooked fruit, determined by an electronic shear press, was of significantly firmer texture.

Design of the roll cooker–cooler is covered by Canadian and United States patent applications.

Immersion Freezing in Freon 12

8

Freezing rates in Freon 12[5] for fruit and vegetable products varied from 15 sec for cored green peppers, asparagus, and 3/16-inch carrot slices to 3 min for ½-inch thick apple sectors and 4 min for pear halves. When samples were thawed, texture of the peppers and asparagus was excellent. Texture of carrots, apples, and pears frozen in Freon 12 was not significantly different from that of samples frozen at −18 F in air.

Immersion freezing in Freon 12 was also used for mashed potatoes, mashed turnips, applesauce, and apricot puree in a new way. The prepared products were forced through an ⅛-inch orifice and dropped into the immersion freezer. The frozen material formed discrete pieces with a light porous texture. Volume of frozen samples was 2.0–2.5 times that of the starting product. The potato and turnip samples remained readily pourable after 6 months' storage at fluctuating freezer temperatures, whereas applesauce and apricot puree particles agglomerated.

Cherry Brining and Candying

Maximum percentage yields of candied fruit based on raw fruit weight were obtained from cherries (Bing and Van varieties) normally considered 2–3 days overmature for brining. This yield figure took into account brining, stemming, and pitting losses and weight changes during candying. Fruit candied at this stage had slightly darker color than desirable but was judged acceptable. Fruit that was 5–6 days overmature for brining yielded up to 11% less finished product than fruit that was 2–3 days overmature.

Processing Plant Waste Disposal

Laboratory studies of the modified activated sludge treatment of processing plant wastes have been completed. Sodium nitrate used as an enrichment of a simulated apple juice waste gave up to 95% removal of organic material (Biological Oxygen Demand). Urea, ammonium nitrate, ammonium phosphate, and ammonium hydroxide were not satisfactory as sources of nitrogen.

PLANT NUTRITION, SOILS, AND IRRIGATION

Calcium Deficiency and Breakdown in Apple

In 2 consecutive years, breakdown in Spartan apple has been sharply reduced by calcium sprays. Sprays of 0.8% calcium nitrate, applied five times each year as a dilute spray, increased the calcium content of the pulp. A very good relationship was found between the calcium content of the pulp and the percentage of apples with breakdown.

Nitrogen and Cultivation Effects on Apples

A 6-year study has shown very little effect of nitrogen applications of 0.5 to 9 lb of ammonium nitrate per tree or of light rototilling in spring or early summer around Starking Delicious trees grown in grass sod. Only at very low levels of applied nitrogen did cultivation have an effect, reducing the stress of sod competition.

[5] Copyright E. I. Dupont Co.

Alar and Mineral Nutrition of Apple

Alar sprays of 1,000 or 2,000 ppm reduced the nitrogen content of Spartan apple leaves and fruit pulp. Calcium was reduced in the leaves, but increased in the pulp. The levels of magnesium, potassium, phorphorus, zinc, manganese, iron, and copper were not appreciably affected by treatment with this growth retardant.

Controlled-release Fertilizer Packets

Perforated polyethylene packets containing magnesium, zinc, and boron fertilizer salts doubled total yield of four cuttings of ryegrass in the greenhouse. The slow, constant release of fertilizer from the packets reduced excessive uptake by the crop. The same elements at the same rate when mixed with the soil resulted in a 25% yield reduction. The addition of nitrogen produced large yield increases, which masked the effect of the other elements, regardless of method of application.

Sulfur Response of Alfalfa Varieties

A variation of 20% occurred in the yields of eight varieties fertilized with sulfur in the form of gypsum (17% S). Du Puits gave the highest with a 32% increase in yield and Rhizoma and Beaver the lowest. This work, now in the fourth crop season, shows clearly that variety must be considered when decisions to fertilize with sulfur are to be made.

PLANT PATHOLOGY

Collar or Crown Rot of Apple Trees

Chemical control—Laboratory experiments showed that Dexon, Chemagro 4497, Lanstan, and sodium dinitro ortho cresol percolated satisfactorily through 6-inch soil columns in concentrations toxic to *Phytophthora cactorum* (Leb. & Cohn) Schroet.

In September 1966 a planting of 78 young trees on MM 104 rootstock was examined to determine the number infected with crown rot. Sixty-five appeared free of this disease; 13 were severely damaged. Dexon 5% granular was applied at 280 g/ft^2 to 31 sites selected at random. In September 1967, 3 of the 34 nontreated trees showed foliage symptoms that indicated severe infection of the crown by *P. cactorum*. There were no such symptoms visible in the foliage of treated trees.

Varietal resistance—The resistance to *P. cactorum* of the seedling progeny of some controlled crosses and a large number of open-pollinated apple varieties and species was evaluated by flooding flats with zoospore suspensions when seedlings were 2–3 weeks old. Some plants of most seedling selections succumbed to damping off. Others appeared to be quite resistant. The percentage that survived varied from zero in one selection to 90 in another. The apomictic species appeared to have the most uniformly high level of resistance.

Nutritional Effects on Bull's-eye Rot of Apples

Studies are being made of the nutrition of the apple perennial canker organism, *Neofabraea perennans* Kienh., and the apple anthracnose organism, *N. malicorticis* (Cordley) Jackson, both of which cause bull's-eye rot of apple fruits.

Light growth of *N. perennans* on synthetic media was traced to unusually high requirements of magnesium and iron, and one or more trace elements, two to five times higher than those characteristically required for optimum growth of fungi. Best growth was on a 4% sucrose medium containing 0.005 M magnesium, 0.002 M sulfate, 2.5 ppm zinc, and 0.04 ppm of copper, molybdenum, and manganese.

Urea was the best form of nitrogen for growth, but only if this material was sterilized by autoclaving; hydroxylamine and ammonia were the breakdown products apparently responsible for the growth stimulation. Both D and L forms of aspartic acid were utilized. *N. perennans* was sensitive to high pH, and nitrate media required heavy buffering with phosphate. Persulfate, usually a good

source of sulfur for fungi, was strongly inhibitory, but growth with sulfite or thiosulfate was close to optimum.

Best growth of *N. malicorticis* was in a nitrate medium supplemented with an extract of cottonseed meal. Some, but not all, of the value of the supplement was from the oil fraction. Neither ferulic acid nor kinetin was required.

Addition of filter-sterilized alcoholic extracts of the bark of Newtown apple trees stimulated rapid and prolific production of macroconidia from all cultures of *N. perennans* but not from *N. malicorticis*.

Virus Diseases

Suppression of the symptoms of apple leaf-pucker disease—Symptoms caused by leaf-pucker virus in Spartan can be suppressed by bud-transmissible agents, presumably viruses, that occur without obvious symptoms in some clones of apple.

When test trees of a Spartan clone that is free from common latent viruses were inoculated by budding with three sources of leaf-pucker virus, the trees showed severe foliage, bark, and fruit symptoms. The same Spartan clone developed no symptoms if buds from any of three "protecting" sources were applied to it within 6 months before or after the time of inoculation.

A virus from golden elder that infects Prunus *spp.*—As elder is a known host of several European stone-fruit viruses, two suspicious-looking cultivars of ornamental golden elder were tested to find out if the golden characteristic might be a symptom of virus infection. *Sambucus racemosa* var. 'Plumosa-aurea' Schwer. was apparently virus-free. However, four sources of *S. nigra* L. 'Aurea' Sweet yielded virus isolates, mechanically transmissible to several species of *Prunus* and to elder seedlings, which developed golden coloration. Serological tests showed no relationship to tobacco-ringspot, tomato-ringspot, or cherry leaf-roll viruses. Symptoms and physical characteristics resembled those of arabis-mosaic virus, which infects sweet cherry in Europe.

Control of Rhizopus Rot in Fresh Peaches

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Commercial treatment of fresh peaches with the fungicide Botran was developed for control of rhizopus rot. Soda ash used in water immersion dumpers was rinsed from the fruit, and a spray of Botran at 4 lb/100 gal of 75% wettable powder was applied. Concentration at the end of the brush line was 14 to 17 ppm. A residue of 20 ppm is allowed on fresh fruit; 10 ppm controls rhizopus.

POMOLOGY

Apple Mutants

Compact growth mutants of the Spartan apple—A number of Spartan selections that originated from scions irradiated with gamma rays several years ago bore their second crop in 1967. A few had normal Spartan fruit and the growth was reduced to about 50% of the standards. These selections are of interest when trees smaller than standard are wanted, but when suitable size-reducing (clonal) rootstocks are not available.

Mildew susceptibility — Twenty-five clones each of Golden Delicious and McIntosh that originated from irradiated material and were selected for desirable growth habit in the nursery were rated for susceptibility to apple powdery mildew in 1966 and 1967. A wide range of variation was recorded, especially in the Golden Delicious variety. Clones both more and less resistant to mildew than the parent varieties were found. The behavior of the same clones was consistent in both years, the year–variety interactions being insignificant.

Superior leaf efficiency of compact apples—Compact or "spur-type" mutants

of Delicious and Golden Delicious were compared with standard strains of these cultivars. The net assimilation rate was approximately 12% higher for both compacts under controlled environment. Morphological measurements of shoots also showed that compacts of both cultivars differed from the standard types in similar ways.

Cherry Breeding

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Self-fertile sweet cherry—Consumer response to fruit of a self-fertile sweet cherry selection, 2C-27-19, was tested in comparison with fruit of the standard commercial sweet cherry variety Lambert. The results showed the selection to be superior in appearance, and also in taste, though to a lesser degree. This self-fertile selection could serve as a pollinizer in plantings of the Lambert variety.

Pruning Methods and Rootstocks

Effect on yield of apples—A comparison was made of four different pruning methods on Delicious apple trees that had been worked on five different rootstocks. The pruning methods were: check, removal only of branches touching the ground and crisscrossing badly (similar to English "regulated"); spindle bush, a minimum of cutting, consisting of tying down branches in early years to promote fruiting and development of a central leader or spindle; pyramid, a cut-back type of pruning designed to stiffen trees and keep them compact; and pillar pruning, designed after the English McLean method, by which fruiting wood is taken from a central leader, each branch being cut back to the trunk when the tree is 3 years old so that renewal branches will develop.

Minimal pruning (check) resulted in highest yield. Spindle pruning gave a well-shaped, sturdy tree and yielded the next highest. Heavy cutting (pyramid and pillar) suppressed bud formation and the trees were smaller. Heaviest bearing to date has been with M IX, M VII, and MM 106 rootstocks.

Chemical Growth Retardants

Suppressant effects on ripening and respiration of apples—Succinic acid 2,2-dimethylhydrazide (Alar) was applied to McIntosh apple trees 2 weeks after bloom. Fruits were harvested weekly throughout the season and respiration measurements were made at 70 F. Matched samples were subjected to either a constant flow of air containing 1,000 ppm ethylene or ethylene-free air. The conclusions were: Alar will delay ripening of apples; ethylene will overcome this delay; Alar interferes with the natural ethylene production of treated fruits; and, because of this ethylene–Alar relationship, it is likely that Alar reduces the auxin level of McIntosh apples.

Fruit Storage

Effects of ethoxyquin on storage scale of apples—Experiments with ethoxyquin showed that if apples were permitted to dry thoroughly after being dipped in ethoxyquin, they could pass through a commercial washer 3 days after treatment without reduction of protection. Detergent was not used, but the fruit was brushed with nylon brushes in the wash section, then rinsed and brush dried.

Untreated Stayman apples developed almost 100% severe scald, whereas the average incidence of scald on fruit dipped in 1,800 ppm ethoxyquin was only 2%. There was no difference in lots washed after 3 days or 21 days, or unwashed after treatment.

Sugars, polyols, and organic acids in apple—Paper and thin-layer chromatography were used in the study of the juice constituents of Spartan apples.

Sugars identified include sucrose, glucose, fructose, and xylose. Two unknown sugars with R_f values greater than the preceding ones were also found. Fructose was the predominant sugar and next in order were glucose, sucrose, and xylose.

Organic acids identified were malic, citramalic, quinic, shikinic, citric, succinic, phosphoric, and chlorogenic. Malic acid constituted over 90% of the total acid content.

Tomatoes

Color comparator—An accurate, economical color comparator was designed for use in grading tomatoes for processing. In laboratory tests it graded more than five times as fast as electronic equipment and there was no significant loss in accuracy.

Effect of mineral nutrition on pH—In 1964 we reported that high levels of nitrogen or phosphorus nutrition produced fruit with a high pH. These findings have been confirmed. High levels of nitrogen, phosphorus, or potassium caused significant increases in pH if other elements were kept at the normal level. Adjustment of the levels of magnesium or calcium had no consistent effect.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

If a common name for a pesticide has not been approved by the Canadian Standards Association, the trade name or temporary designation has been used. The manufacturers of pesticides identified by trade names are:

Trade name	*Manufacturer*
Alar	UniRoyal Chemical Company
Chemagro 4497	Chemagro Corporation
Dexon	Chemagro Corporation
Dyfonate	Stauffer Chemical Company
Ethoxyquin	Monsanto Chemical Company
Galecron	CIBA Company Limited
Lanstan	Niagara Chemical Company
Micasin	Green Cross Products
Morestan	Chemagro Corporation
NC-5016	Fisons (Canada) Limited
Niagara 10242	Niagara Chemical Company
Plictran	Dow Chemical Company
Temik	Union Carbide Chemicals

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Research Station
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J. Raine, B.S.A., M.S.	Cane fruit insects; leafhopper virus vectors
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F. C. Mellor (Miss), B.S.A.	Strawberry viruses; thermotherapy
H. S. Pepin, B.S.A., M.A., Ph.D.	Root rots; red stele of strawberry
M. J. Pratt, B.Sc., Ph.D.	Forage crop diseases; legume viruses
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H. W. J. Ragetli, Ir., Ph.D.	Organic chemistry; virology
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Departures

F. J. Welwood (Mrs.), B.A. Resigned May 4, 1967	Librarian
D. D. Carstea, Agr. E., M.Sc., Ph.D. Probation terminated June 30, 1967	Mineralogy
H. G. Fulton, B.S.A. Retired December 19, 1967	Entomology

VISITING SCIENTISTS

H. S. Chachoria, B.Sc., M.Sc. Colombo Plan, 1966–67	Entomology

INTRODUCTION

This is the fifth report of the Research Station, Vancouver. It covers the work in 1967.

In the past we have published biennial reports. Starting with this report, we expect to publish annually. Both the report and reprints of the publications are available on request. Correspondence should be addressed: Research Station, 6660 N.W. Marine Drive, Vancouver 8, B.C., Canada.

R. E. Fitzpatrick
Director

[5] Appointed September 25, 1967.

VIRUS CHEMISTRY AND PHYSIOLOGY

Physiology and cytology of virus-infected plants—Metabolic changes in leaf tissues with localized virus infections had been attributed, in the early phases of infection, to increase in mitochondrial enzymes. A study of the role of phenolases showed that while crude leaf extracts of healthy *Nicotiana glutinosa* L. were unable to oxidize tyrosine, extracts made after infection with tobacco mosaic virus oxidized tyrosine rapidly, the rate increasing with the development of necrosis. These results can be consistently correlated with the disruption of chloroplasts and mitochondria in cells, as observed with the electron microscope.

Continued investigation of cytological effects of localized virus infection showed that a few small packets of tobacco mosaic virus (TMV) could be found in necrotic leaf cells of *N. glutinosa* when samples were pre-fixed in glutaraldehyde. Detaching the inoculated leaf from the plant resulted in a 30-fold increase in virus concentration, and a similar increase was detected when the inoculated plants were kept at 26 C. A still greater increase in concentration was effected by incubating detached leaves at 26 C, when the arrangement of virus came to resemble that of a systemic virus infection. In cells of *Chenopodium amaranticolor* Coste & Reyn., local lesions presented virus characteristic of a systemic infection in concentration and arrangement, neither of which was affected by detaching the leaf or by changing the air temperature.

Viral cytopathogenicity and function—It was postulated that plant viruses are multifunctional pathogens whose cytopathogenicity results not so much from their ability to induce the host cell to replicate virus as from their ability to affect actively host cell metabolism and processes at all levels of cellular activity. Evidence was presented that the various viral functions are separable and that total loss of any one function results in different types of incomplete virus, some of which may require a helper virus in order to be perpetuated. It was pointed out that the cytopathic viral function expresses itself by initiating and maintaining degenerative as well as synthetic cellular activities. The former might result from the induction of cytotoxic proteins. However, synthetic cellular activities, such as the two- to three-fold increase in mitochondria in *Nicotiana glutinosa* cells infected with TMV, were considered to reflect virus interference at the host genome level.

Physicochemical characterization of plant viruses—The composition of carnation ringspot virus based on nucleotides and amino acids recovered was 20.5% ribonucleic acid (RNA) and 79.5% protein. Analyses indicated that the subunit protein comprised approximately 347 amino acid residues, which had a subunit molecular weight of 38,000. The sedimentation velocity and extinction coefficient were 132 *S* and 6.46 cm^2/mg, respectively. The molecular weight of the virus, based on sedimentation and diffusion, was 7.07×10^6.

Immunochemistry of plant viruses—Sera obtained from rabbits injected with increasing quantities of the bean or cowpea strains of southern bean mosaic virus were tested for content of strain-specific and cross-reactive antibodies. The proportion of strain-specific antibodies decreased as the titer increased during the course of immunization. The proportions of strain-specific antibodies in each of the 19 *S* macroglobulin and 7 *S* immunoglobulin fractions and in the whole serum were found to be similar with either primary or secondary response sera. The electrophoretic properties of the strains differed within the pH range of 4 to 8.

Purification of plant viruses by gel-filtration—The ion-exchange capacity of Sephadex G25, which was elicited when the adsorbed material was eluted with water, was used as an alternative method for purification of turnip mosaic virus (TuMV). Under these conditions TuMV was well separated from components that otherwise caused irreversible polymerization of the virus particles.

Inhibitors of plant ribonuclease—Enzyme kinetics and X-ray diffraction studies indicated that the mechanism of inhibition of ribonuclease by bentonite could not be attributed completely to an ion-exchange effect as previously postulated. The conformational structure of the enzyme molecule plays a very important role.

Potatoes

Potato leaf roll virus—A search for overwintering herbaceous hosts of the green peach aphid, *Myzus persicae* (Sulzer), was conducted in the lower Fraser Valley during January and February, 1967. Living nymphs were found on steckling sugar beets, Brussels sprouts, Chinese cabbage, swede turnip, pineapple weed, hedge mustard, and tall buttercup.

The 1967 flight of *M. persicae* in the lower Fraser Valley began in mid-June, reached a peak early in August, and ended early in September. Water traps were located in Delta, Richmond, Coquitlam, Surrey, Langley, and Matsqui municipalities. The average per trap catch was 1,008 in Delta, 145 in Richmond, and less than 20 in the other districts. In Delta the average catch per trap was 2,711 in sugar beet fields and 161 in potato fields. Sugar beet, of which about 500 acres are grown as a seed crop in Delta, is undoubtedly an important overwintering host. It is significant that more aphids were caught in sugar beet fields than in potato fields in the same district. The short distance traveled by aphids in 1967 resulted in only local infestations of potato.

Plots grown in 1967 showed that spread of potato leaf roll virus (PLRV) in 1966 was negligible before the end of July but increased steadily thereafter. Twenty percent of the tubers collected on September 6 produced infected plants.

Seed pieces from 329 potato tubers, each from a previously tested clone, were grown in the greenhouse and checked for infection by mild strains of PLRV. Green peach aphids were used as vectors and *Physalis floridana* Rydb. as test plants. Only one infected tuber was found.

Potato virus X and potato virus S—Potato viruses X (PVX) and S (PVS) were eradicated from several potato varieties that were infected with either or both viruses by combining thermotherapy with nutrient culture of axillary buds. Plants were grown under diurnal light with air temperatures alternating from 33 to 37 C and soil temperatures from 30 to 32 C. At intervals during treatment, shoots were removed from treated plants and axillary buds were excised and cultured on nutrient media. Most of the buds excised were 0.3–1.0 mm long, and included the meristematic dome and two or three leaf primordia. Survival of buds on culture media has varied from over 50% to less than 10% in different experiments. Survival depends mainly on the culture medium and the size of the buds. Liquid medium was superior to solid; large buds rooted better than small ones. The size of the bud was of critical importance in virus eradication from buds taken after short treatment or without treatment, but of less importance as the duration of the heat treatment lengthened. Potato varieties that have been treated and are now free of PVX and PVS include: Canus, Cariboo, Early Epicure, Early Rose, Fundy, Green Mountain, Irish Cobbler, Kennebec, Netted Gem, Norgold Russet, Norland, Pontiac, Warba, and White Rose. Some of the varieties still contain rod-shaped particles visible in the electron microscope. The identity of these particles is being investigated.

Seven varieties from which either PVX or PVS or both were eradicated during the winter of 1966–67 were grown in a field plot in Pemberton, B.C., by a Foundation Seed grower. The plants in the field grew from stem cuttings rooted in sand in the greenhouse. Serological tests confirmed that the plants were free of PVX and PVS and indicated that no contamination occurred during the summer. Sufficient seed of Netted Gem and White Rose varieties is available to plant 3 to 5 acres of each in 1968.

Rhizoctonia—Broadcast applications of quintozene or Terraclor Super-X to clay loam soil at 30 lb/acre of actual quintozene reduced stem infections on Warba and Netted Gem potato. Marketable and total yields of Warba potato were increased when 60 lb/acre of quintozene was applied. The granular formulation of Terraclor Super-X applied at 25 lb/acre of quintozene reduced stem cankers and tuber-borne sclerotia on Netted Gem potato but did not affect yield. Applications of quintozene at rates up to 20 lb/acre to open furrows before planting gave unsatisfactory disease control.

Small Fruit Diseases

Resistance of blueberry varieties to mummy berry—Seventeen varieties of cultivated highbush blueberry and two native species growing in nearby bogs were examined for ascospore infection with *Monilinia vaccinii-corymbosi* (Reade) Honey. They were rated for foliar and for flower cluster infection and for overall susceptibility. Two varieties, Dixie and Rubel, and two species, *Vaccinium myrtilloides* Michx. and *V. uliginosum* L, were resistant. Pemberton, Concord, Jersey, and Johnston were moderately susceptible; Weymouth, Rancocas, June, Bluecrop, Blueray, Coville, Burlington, Pioneer, Stanley, Charlotte, and Earliblue were very susceptible.

Very susceptible varieties may be divided into three groups according to the degree of leaf or flower cluster infection. Varieties having significantly more leaf infection than flower cluster infection were Bluecrop, Earliblue, and Stanley. Varieties with more flower cluster infection were Burlington, Blueray, Coville, June, Pioneer, Charlotte, and Weymouth. Rancocas had leaf and flower clusters equally infected. All the moderately susceptible varieties showed a strong tendency toward blossom cluster infection.

Powdery mildew and gray mold in strawberries and raspberries—Fungicide 1991, a systemic fungicide, showed considerable potential for the control of gray mold and powdery mildew in strawberries and raspberries. Berry infection by both fungi was practically eliminated in Stelemaster strawberries when the fungicide was applied at 0.25 lb/acre. Fungicide 1991 proved as effective as captan, dichlofluanid, and DAC 2787 for preharvest fruit rot control in Willamette raspberries, and was more effective for postharvest rot control. Dichlofluanid reduced berry size, but captan, DAC 2787, and Fungicide 1991 tended to increase the size. Fungicide 1991 was equally as effective as dinocap and slightly better than sulfur for the control of powdery mildew on the leaves of Northwest strawberries. Repeated applications of Fungicide 1991 at intervals of about 14 days were required to control powdery mildew when the disease was active.

Forage Legume Diseases

Clover viruses in Eastern Canada—A limited survey of clover fields in Ontario, Quebec, and the Atlantic provinces showed the presence of seven viruses. Wisconsin pea streak was the most commonly found virus and occurred in most of the fields in New Brunswick, Nova Scotia, and the Ottawa Valley. Clover phyllody virus occurred in Prince Edward Island, Nova Scotia, New Brunswick, and Quebec, and tended to decrease in incidence from east to west. A virus resembling clover yellow vein virus, which was recently described in England, was found in Quebec, New Brunswick, and Prince Edward Island. Alfalfa mosaic, bean yellow mosaic, red clover vein mosaic, and white clover mosaic viruses were sporadically present in most of the areas surveyed.

Viruses were not the main limiting factors in yield and maintenance of clovers in the areas surveyed, with the possible exception of clover phyllody virus in a few fields. In southeastern Ontario, red clover, which lasted only 1 or 2 years, had a low incidence of virus infection.

Growth of virus-infected clover under suboptimal conditions—In growth chambers held at 10 C white clover infected with clover yellow mosaic virus grew vigorously on a long-day regime. On a short-day regime at this temperature, infected plants were badly stunted in comparison with uninfected control plants. This stunting has been observed as a symptom of virus infection of white clover in the late fall and early spring in the field. Chlorophyll and photosynthetic 18 S protein concentrations in leaves of virus-infected plants were about half those of the healthy controls for both light regimes in the growth-chamber experiment. It is inferred that the stunting is due mainly to decreased photosynthetic capacity of inflected plants growing in cool temperatures where light conditions are limiting.

Aphids

Many additions were made to the list of aphids of British Columbia, based on collections from identified hosts and catches in yellow pan water traps.

Masonaphis maxima (Mason)—A 2-year study of this species on thimbleberry, *Rubus parviflorus* Nutt., revealed an unusual life history. The eggs hatched in late March or early April, and the fundatrices matured and reproduced a month later. Males and females were produced in late May or in June and egg-laying had started by July. This early commencement of egg-laying coincided with the cessation of production of new growth by the host plant.

Dispersal of winged aphids—All the aphids caught in yellow pan water traps at two locations in Chilliwack and at one location in Richmond were mounted and identified. The following potentially important vector species occurred in sufficient numbers to give meaningful data on their movements: *Aphis fabae* Scop., *A. helianthi–heraclella* complex, *Brachycaudus helichrysi* (Kltb.), *Brevicoryne brassicae* (L.), *Cavariella aegopodii* (Scop.), *Chaetosiphon fragaefolii* (Cock.), *Hayhurstia atriplicis* (L.), *Hyperomyzus lactucae* (L.), *Myzus ascalonicus* Donc., *M. persicae* (Sulz.), *Macrosiphum avenae* (F.), *M. euphorbiae* (Thos.), *M. fragariae* Wlk., *Metopolophium dirhodum* (Wlk.), and *Rhopalosiphum padi* (L.).

Life tables—Individual, clonal *Acyrthosiphon pisum* (Harris) and *Aphis fabae* Scopoli were reared in a controlled environment (20 C, 70–80% relative humidity, and 16 hr of light/day) on field bean, *Vicia faba* L. var. Exhibition Long Pod, which promoted rapid population growth and development of large, healthy, apterous females. Each of 47 *A. pisum* and 69 *A. fabae* was examined daily from birth until death. Progeny were recorded and removed daily from each aphid. Age-specific survival and fecundity tables were constructed and used to compute intrinsic rates of natural increase (r_m). For *A. pisum* and *A. fabae*, the mean prereproductive periods were respectively, 7.57 ± 0.17 and 6.6 ± 0.65 days; the mean reproductive periods were 11.27 ± 2.35 and 17.45 ± 4.15 days; the mean postreproductive periods were 6.16 ± 4.58 and 7.62 ± 5.22 days; and the mean fecundities were 96.72 ± 22.92 and 79.12 ± 15.95 nymphs.

Prereproductive and reproductive mortalities were not important in either species, since 33 (70%) *A. pisum* and 38 (55%) *A. fabae* were still alive 24 and 25 days, respectively, after their peak in mean daily nymph production had been attained; the last *A. pisum* died on the 45th day and the last *A. fabae* on the 44th.

The intrinsic rate of natural increase of *A. pisum* was 0.404 ♀/♀ per day, while that of *A. fabae* was 0.359 ♀/♀ per day. Thus, under the conditions of the experiment in 14 days, 100 apterous *A. pisum* would produce 19,145 individuals and *A. fabae* would produce 10,607.

Morphology and fine structure of virus vectors—A study on the morphology of the labium of the green peach aphid, *M. persicae*, and of the pea aphid, *A. pisum*, is in progress. Emphasis is on the types, distribution, and fine structure of the sense organs.

Examination in the electron microscope of cross sections of the stylet bundle of the leafhoppers, *Aphrodes* sp., *Macrosteles fascifrons* (Stål), and *Scaphytopius delongi* Young, showed central canals with nerves in both the maxillary and mandibular stylets.

Leafhoppers

Transmission of plant viruses—Scleroracus dasidus Med. and *Scleroracus balli* Med. transmitted witches'-broom virus (WBV) from clover and alfalfa to clover, alfalfa, and potato; and from potato to clover, but not from potato to potato. This is the first record of transmission of WBV of potato by insects in North America. The same species also transmitted clover phyllody virus (CPV) from clover to clover and potato.

Aphrodes bicinctus Curt. transmitted CPV from clover to clover but not to strawberry. This species was collected from

clover fields in which occasional plants were infected with CPV and adjacent to strawberry fields severely infected with green petal and WBV.

M. fascifrons transmitted aster yellows virus (AYV) from plantain to aster, carrot, periwinkle, celery, and clover but not to potato. This is the first record of transmission of AYV by insects in British Columbia. The species was collected in the Cariboo district from weeds and potatoes that showed severe symptoms of AYV.

Root Weevils

In blueberry and strawberry—Leaves of the blueberry variety Weymouth were shown to be unacceptable to adult black vine weevils, *Brachyrhinus sulcatus* (F.). Leaves of the varieties Rancocas, Pemberton, Jersey, Blue Crop, Stanley, Dixie, Rubel, and June, a parent of Weymouth, were acceptable, but those of the variety Cabot were not. Cabot is the other parent of Weymouth. In the laboratory weevils fed on leaves of the unacceptable varieties had a low feeding rate and did not survive to oviposit. The leaf factor responsible for the low feeding rate and death before ovipositing is not known.

The chemosterilant, Apholate, was fed to adults of the black vine weevil to determine if this material would render these wholly parthenogenetic females sterile for life. Excised strawberry leaflets were dipped in various concentrations of Apholate in water and fed to individual adults. The numbers and viability of the eggs were reduced substantially according to the concentration used. However, when the chemical was omitted, the weevils reverted to producing normal numbers of viable eggs. Therefore Apholate did not cause permanent sterility in this species.

Since soil insecticides are no longer recommended for controlling larvae of the *Brachyrhinus* root weevils, the adults are now controlled with foliar applications of short-lived insecticides. Recently, in other areas, malathion has been applied to certain crops in the undiluted form at very low rates per acre. A small testing tower was constructed for a preliminary laboratory trial against adult black vine weevils. Undiluted technical malathion was injected by a micrometer-driven syringe from the top of the tower into a downward-directed air stream. The very small droplets so formed impinged on the foliage of a strawberry plant 0.9 m beneath. Weevils were caged on the foliage immediately and 16 days later. The effectiveness of very small amounts of the undiluted material was demonstrated, as well as its unusual persistence under laboratory conditions. However, methods for field application will require considerable experimentation.

Wireworms

Chemical control—In field populations of 26.6 European wireworms, *Agriotes obscurus* L., per sq ft, single applications were made just before seeding field corn, of the following insecticides: Dyfonate, Furadan, parathion, and Bay 37289, all in the 10% granular formulation, and Dyfonate 67% emulsion. The rate in all cases was 4 lb toxicant/acre, and each material was worked into the top 4 inches of soil. In the untreated plots 94% of the plants were destroyed, and in the plots treated with Bay 37289, 64%. The other insecticides gave good protection and comparable yields.

The same materials, except Dyfonate, in the 10% granular formulation were applied in the seed furrow at 10 oz/1,000 feet, or 14.6 oz toxicant/acre. In the treated plots from 0 to 14% of the plants were destroyed, whereas in the untreated plots 79% were lost. There was no apparent toxicity.

Leatherjackets

Chemical control—Larvae of the recently introduced marsh crane fly, *Tipula paludosa* Mg., continued to cause severe damage to lawns and pastures in the lower Fraser Valley. Heavy infestations were found in pastures of dairy farms 20 miles east of Vancouver and in lawns 30 miles further east.

On March 29 insecticides were sprayed on infested sod land at 3 lb toxicant/acre in 100 gal water. DDT was effective, Baygon, Bay 37289, and diazinon were fairly effective, but carbaryl, naled, malathion, and methoxychlor were not effective.

On May 13 spray applications of parathion at 1 lb and 0.5 lb toxicant/acre

gave good control, with little difference between the two rates; trichlorfon at the same rates and Dyfonate at 1 lb toxicant/acre gave no control.

Root Maggots

Compatibility—The insecticides, fensulfothion and thionazin (Dasanit and Zinophos), were applied to plots in silt loam, singly or with preplant, preemergence, postemergence, and stale seedbed herbicidal treatments. Fensulfothion and thionazin were applied as split applications to broccoli, cabbage, and cauliflower at 2 oz toxicant/1,000 feet in a band at seeding and as a drench, at the same rate, 28 days after seeding. Rutabaga was treated at seeding as described and with drench applications in the rows at 2 oz/1,000 feet, 28, 49, and 70 days after seeding. Damage was assessed by grading the roots at harvest and allotting an index from which percentage damage was calculated. Of the stem crucifers, broccoli had the least maggot damage, cabbage and cauliflower had about equal damage, and rutabaga had the most. Fensulfothion was slightly superior to thionazin in maggot control. None of the herbicides had any insecticidal value.

Preplant herbicide treatments with CDEC, DCPA, EPTC, SD-11831, and Trifluralin, with or without the insecticides, had no appreciable effects on yield.

Preemergence herbicide treatments with C7019, OCS21693, and VCS365 showed some incompatibilities with fensulfothion and thionazin. C7019 alone killed cauliflower and rutabaga but broccoli and cabbage were tolerant; in combination with the insecticides it depressed yields. Only broccoli survived treatment with VCS365. The susceptibility of the crucifers to maggots was in the same order as above.

Preemergence and postemergence herbicide treatments with various rates of Dicamba, Nitrofen, and R-11913 caused various degrees of phytotoxicity. R-11913 was phytotoxic to the stem brassicas but less so to rutabaga. Nitrofen caused considerable leaf curling, especially to cabbage. Fensulfothion, and to some extent thionazin, tended to increase this injury, and dicamba caused slight curling of the leaves.

Stale seedbed weed control with treatments of diquat and paraquat at two rates combined with applications of fensulfothion and thionazin caused little phytotoxicity.

Insecticides with and without combinations of fungicides and acidic or basic starter solutions were applied in the transplant water for maggot and clubroot control. The materials were used in 50 gal water as follows: the insecticides, fensulfothion, diazinon, Birlane, Furadan, and thionazin all at 3 oz toxicant; the fungicides, mercuric chloride at 8 oz and Terraclor (quintozene) at 3 lb of 75W; and the starter solutions, dibasic ammonium phosphate at 3 lb and phosphoric acid at 80 fl oz. The dose per plant was 8 oz of the transplant water. Every insecticide was tested alone and in combination with each fungicide with and without the starter solutions and applied at the same rate of liquid per plant.

Maggot damage was severe in plots where no insecticide was present. Mercuric chloride gave some protection from maggot damage but tended to retard early growth, and it appeared to be incompatible with the organophosphorus (OP) insecticides, allowing more maggot damage in the roots than when OP materials were applied without the fungicide. Mercuric chloride appeared to offer better protection from clubroot than Terraclor. Many plants that were infected by clubroot and were under attack by maggots produced marketable heads if they survived for 6 weeks after transplanting. Diazinon was the least effective insecticide and the systemic properties of Furadan delayed an infestation of cabbage aphid until harvest.

Organophosphorus residues in carrots—OP insecticides were applied in the furrow in muck soil with carrot seed for control of cyclodiene-resistant carrot rust fly, *Psila rosae* (F.). Fensulfothion and thionazin at 1 and 2 lb toxicant/acre in the furrow received four additional drench treatments at 1 lb/acre 28, 49, 70, and 91 days after seeding. These unregistered materials were effective and may be future replacements for diazinon when residue studies on them are complete.

Diazinon applied at 2 lb/acre in the furrows received weekly drenches at 10

oz, 20 oz, and 30 oz, that is, 1×, 2×, and 3× the recommended rate, starting 28 days after seeding and terminating August 28, 18 weeks after seeding (14 drenches). Samples of carrots from the diazinon treatments were extracted in acetonitrile, cleaned up by column chromatography, and the residues determined by gas chromatography with electron capture detection. Seven days after the last application, diazinon residues were present at all levels of treatment; those at 2× and 3× rates were above tolerance. Detectable residues were present 70 days after the last application and were still above tolerance at the 3× rate.

Residue Chemistry

D–D residues in soil—D–D mixture was applied in the fall at 200 gal/acre to muck soil and 100 gal/acre to sandy loam to control the golden nematode, *Heterodera rostochiensis* Woll., on Vancouver Island. Eight months later, representative samples of each soil were taken for analysis.

A rapid test for the presence of dichloropropene residues was developed. It consisted of analyzing the vapor above the soil by gas chromatography with electron capture detection. Positive results were obtained from both types of soil.

Possible quantitative methods of analysis were studied. The most satisfactory was extraction with acetonitrile followed by partitioning into *n*-hexane and gas chromatographic analysis of the extract with electron capture detection. From the 4-inch level in muck treated with 200 gal/acre recovery was: 1.4 ppm of *cis*-1,3-dichloropropene and 3.2 ppm of the *trans* isomer; at 8 inches they were 1.8 and 4.8 ppm, respectively. From the same levels in sandy loam, recoveries were: zero at 4 inches, but 0.30 and 0.39 ppm, respectively, at 8 inches.

Extraction of organochlorine residues from soil—Methods of extracting organochlorine pesticides from soil were studied. Of those tested, Soxhlet extraction with a hexane–acetone mixture was the most efficient. The presence of at least 5% water was found to be necessary for good extraction and up to 40% water had no detrimental effect.

Advisory Work

Insect inquiries are received from industry, government departments, and the public. The following are some examples of subjects.

Ants—Two species, *Camponotus herculeanus* (L.) whose winged forms appear in May and *Lasius sitkaensis* Pergande whose winged forms appear in August, are the common house-infesting ants. The former are sometimes found in large numbers in houses of post-and-beam construction and the latter in standard frame houses.

Firebrats—Lepismodes inquilinus Newman, generally known as *Thermobia domestica* (Pack.), is a pest in new and old apartment buildings. It is readily spread in the belongings of tenants.

Golden spider beetles—Niptus hololeucus Fald. is a comparatively rare ptinid in the province. It appeared in very large numbers in an old feed warehouse at Kaslo, B.C.

Varied carpet beetles—Anthrenus verbasci (L.) remains the main household insect in the province, surpassing the clothes moth as a pest of wool. A flour warehouse in Vancouver was heavily infested.

A dermestid—Trogoderma inclusum LeConte became a problem at the Research Station at Summerland in a room where codling moths were reared. The room was fumigated with methyl bromide. Data are being collected on the concentrations necessary to kill these larvae.

Merchant grain beetle—Oryzaephilus mercator Fauv. is the subject of twice as many inquiries as the closely-related sawtoothed grain beetle.

Termites—Zootermopsis angusticollis (Hagen) is increasingly associated with damp conditions in buildings.

PEDOLOGY

Chief activities during the past year concerned basic and special soil surveys, and the land inventory projects instituted under ARDA within the area delineated by the boundary of the Canada Land Inventory in the province. Personnel have continued to cooperate actively in research projects with federal, provincial, and university departments.

Basic Soil Surveys

Quesnel map sheet, 93G S.E. and 93B N.E.—The map and report for this map sheet, covering some 1.8 million acres, has been completed.

Fort Nelson area, 94J N.E.—This study was started in July 1967 in order to determine the extent and location of potentially arable lands in the Fort Nelson basin. Some 700,000 acres were surveyed. Because of its inaccessibility, about three-quarters of the area was surveyed from a helicopter. The final draft of the soil map and report will be completed by April 1968.

Williams Lake – Alexis Creek, 93G S.E. and 93B N.E.—Work on the project, which was started in 1966, was extended westward in 1967, when inspections of the soils were carried out along existing roads and trails. Some 800,000 acres were covered.

The mapping and final checking of this map sheet will be completed in 1969 by making extensive use of helicopters to gain access to the unsettled areas.

Bonaparte River, 92P W.—This project was started in 1967, when approximately 1 million acres were surveyed in the north half. About a million acres remain to be mapped, and the project should be completed in late 1968. In conjunction with the field work, laboratory analyses are being carried out on representative soil samples.

Fontas River and Petitot River map sheets, 94I and 94P—The objective of the exploratory survey of the areas of the Fontas, Hay, and Petitot rivers in the extreme northeast of the province is to find out the approximate location and extent of land having potential for agriculture or forestry and to determine the feasibility of making a soil survey of the area.

Most of this area was classed as organic terrain. Lands usable for agriculture or forestry were found along the Fontas, Sikanni Chief, and Hay rivers and on the slopes surrounding the Etsho plateau.

Inaccessibility, distance from market, adverse climate, susceptibility to erosion, high clearing costs, and uneconomical size of the land units impose serious limitations and hazards to development. Approximately 6 million acres were covered.

Soil Capability for Agriculture and Forestry Studies

The Canada Land Inventory soil capability project, started in 1963, has been continued under the supervision of senior personnel with survey, laboratory, drafting, and stenographic assistance. The main phase consists of the preparation of soil capability maps and reports for the surveyed areas. Increased demands for soil survey information considered necessary in planning for forestry and wildlife have necessitated considerable committee work and correlation studies with federal and provincial organizations in order to establish soil criteria and climatic parameters for evaluation of capability.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

The manufacturers of the pesticides identified by trade names or coded numbers in this report are as follows:

Trade name	*Manufacturer*
Apholate	Olin Mathieson Chemical Corporation
Bay 37289	Chemagro Corporation
Baygon	Chemagro Corporation

Trade name	*Manufacturer*
Birlane	Allied Chemical Corporation
C-7019	CIBA Company Limited
DAC-2787	Diamond Alkali Company
Dyfonate	Stauffer Chemical Company
Fungicide 1991	Dupont of Canada Limited
Furadan	FMC Corporation
Nitrofen	Rohm and Haas Company
OCS-21693	Velsicol Chemical Corporation
R-11913	Stauffer Chemical Company
Planavin	Shell Development Company
VSC-365	Velsicol Chemical Corporation

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Research Station
St. John's West, Newfoundland

PROFESSIONAL STAFF

H. W. R. Chancey,[1] B.S.A., M.S.A.	Director

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Ray F. Morris,[2] B.S.A., M.Sc.	Head of Section Vegetable insects
G. T. Morgan, B.Sc., M.Sc.	Nematodes

Horticulture Section

B. G. Penney, B.Sc., M.Sc.	Vegetable crops

Plant Breeding and Pathology Section

O. A. Olsen, B.S.A., M.Sc., Ph.D.	Head of Section Potato breeding and diseases
K. G. Proudfoot,[3] B.Agr., M.Agr.	Potato breeding

Soils and Agronomy Section

A. F. Rayment, B.Sc., M.Sc.	Soil fertility
P. K. Heringa, B.Sc., M.Sc.	Pedology
A. G. Valenti,[4] B.Sc., Dr. (Geol.), M.Sc.	Soil survey

INTRODUCTION

This report summarizes the important aspects of research conducted in 1967. Record drought conditions during June, July, and August in eastern Newfoundland adversely affected vegetable and small fruit variety trials at the Station.

At present emphasis is on research into: reclamation and capability of peat

[1] On leave of absence, August 1967 to July 1968.
[2] Acting Director, August 1967 to July 1968.
[3] Appointed October 1967.
[4] Appointed May 1967.

soils; potato breeding for resistance to wart and golden nematode; adaptation trials of vegetables, small fruits, and forages on peat and mineral soils; and control of weeds, insects, plant diseases, and nematodes.

Soil survey reports and agricultural capability maps for the Avalon Peninsula are nearing completion and those for the Gander and Gambo areas are in the process of publication.

Two new potato seedlings, developed at the Station, that are highly resistant to wart performed very well in replicated yield trials in five localities across the province. After further evaluation in 1968, naming and releasing of one or both varieties is anticipated.

Research facilities at the Station were greatly improved by the addition of three greenhouses to the new laboratory building.

Our Director, Mr. H. W. R. Chancey, was granted a year's leave of absence from August 1, 1967, to work with the Newfoundland Department of Mines, Agriculture, and Resources as a Deputy Minister.

R. F. Morris
Acting Director

SOIL SCIENCE

Soil Survey

Soil survey field work was conducted in the northern part of the Avalon Peninsula from Bay de Verde south toward Whitbourne and Markland. More than 250,000 acres were surveyed and sampled. The identification and classification of these soils by chemical analyses has been completed. Capability maps for agriculture are being prepared in conjunction with the soil survey.

Good progress is being made in preparing the final report with maps of the Gander and Gambo areas, comprising 500,000 acres, and publication is expected soon. Capability maps for agriculture will be included with the report.

About 760 soil samples were analyzed, and fertilizer recommendations were made to farmers and gardeners. Soil-test calibration studies were made to determine more accurately the fertilizer requirements.

Further investigations into the occurrence of hardpans in the soil showed the presence of iron–humus, iron–manganese, and humus–silica pans at different locations. A publication on iron pans was completed.

Preliminary work to determine the cause of flashets (muck ponds) suggests a higher nutrient content and subsurface springs as causes of their development.

Other research was directed towards the classification of organic soils and the seasonal changes in the color of soils. A change in soil color, used as a diagnostic aid in soil classification and as a measure of chemical reduction taking place, was recorded during the year.

Peat Soils

Fertility—Experiments on the effects of initial fertility treatments of forage crops on virgin peats were repeated in order to reassess some points that were in doubt. Results showed that a high level of N in the seeding year considerably increased the effectiveness of initial P, especially those treatments receiving only 24.6 lb of P/acre with no maintenance P.

There was further supporting evidence that a high rate of K in the seeding year had little effect on legume establishment and did not prevent winterkilling. Winterkilling appeared to be associated with vigorous legume growth in the year of seeding, which, as previously shown, was promoted by high rates of P fertilization.

Additional greenhouse experiments on the interaction of sources and rates of P with limestone treatments on peat soils have shown that, although radishes responded quite well to rock phosphate, swede turnips responded best to superphosphate when soil pH was raised to 4.6 or higher. The toxic effects of excessively high levels of P from superphosphate

(394 lb P/acre as compared with 197) could only partly be attributed to the depression of soil pH by superphosphate.

Drainage—The effects on water tables and forage yields of open ditch spacings varying from 50 to 150 ft and depths from 1 to 4 ft were mentioned in the 1954–1964 Research Report of this station. For production of vegetables and other special crops, a covered ditch system similar to one used in Norway with spacings ranging from 25 to 100 ft, plus supplementary drainage by ridging, was studied for effect on yields of oats, swede turnips, potatoes, and alfalfa.

A 2-year comparison of the effect of ditch spacing, with and without ridging, was obtained on oat fodder yields. Under fairly wet conditions the first year, ridging improved yields if ditches were far apart, but its effect diminished as the distance between ditches decreased. Under quite dry conditions the second year, overall yields were better and the effect of ditch spacing practically disappeared, though ridging was beneficial on virgin soil.

Data on swede turnips and potatoes, available only for the dry year, showed small yield responses to the narrower ditch spacing. Ridges were consistently better for potatoes. With the wide ditch spacing, ridges were of some benefit to swede turnips also.

In preliminary seedings, with and without ridges, Rhizoma alfalfa proved capable of persisting for 4 years in ridged culture in drainage treatments with up to 100 ft between ditches, but the results were better where spaces were 75 ft or less. On the flat, alfalfa persisted only in the immediate neighborhood of ditches. Spot yield checks on a single row showed yield potentials higher than 5 tons of dry matter per acre.

ANIMAL SCIENCE

Grazing Trials on Peat Pastures

Research on mineral nutrition for yearling Hereford steers pastured on peat soil was continued. In previous experiments a mineral supplement provided ad lib. failed to give any response in animal gains, but in the past season fritted trace elements applied to the soil in place of the mineral supplement gave good indications of a response, not verified statistically. Responses to access to some rough grazing on mineral soil (browse) were considerably less. The comparative daily gains for a 120-day grazing period were: check 1.80 lb, minerals 1.99 lb, browse 1.90 lb, minerals and browse 2.08 lb. Injections of selenium as sodium selenate to half of the animals produced no direct effect, though the possibility of a browse–selenium interaction cannot be excluded. Selenium seemed to benefit the groups that had access to browse on rough mineral soil. Internal parasites, which interfered previously with nutritional experiments, were controlled by treatment with thiabendazole given to the steers before they went on pasture.

New pastures were seeded specifically to investigate interactions between different forage mixtures and the mineral nutrition of animals. Sheep will be substituted for cattle in order to get better replication.

All-grain Laying Diets for Poultry

In a laying trial, a diet that contained no protein supplement gave 59.0% production, and a control diet adequate in protein gave 72.0% production. Egg weights and body weight gains were also depressed on the low-protein diet, which consisted of equal parts of wheat and oats, fortified with 3% alfalfa meal and vitamin and mineral supplements.

When the low-protein diet was supplemented with 0.1% lysine HCl, egg production rose to 65.5%, and egg weights and body weights were increased significantly. The addition of 0.1% DL-methionine elicited no response, whether added alone or in conjunction with lysine, which suggests that insufficient lysine was added, since methionine was calculated to be the second limiting amino acid. The addition of 2% fishmeal to the low-protein diet

increased egg production to 69.3%, which was not significantly lower than production on the control diet. There were four replicate floor pens with over 150 birds per treatment, and the duration of the test was 336 days.

PLANT SCIENCE

Vegetable Varieties

Variety testing was continued for adaptability and yield on both mineral and peat soils. Owing to near-drought conditions early cabbage and cauliflower crops on mineral soils were poor, and on peat soils midseason cabbage and broccoli yields were reduced. Late cabbage and Brussels sprouts were destroyed by an infestation of black leaf spot, *Alternaria brassicicola* (Schw.). Results obtained were similar to those reported in 1964–1966 except for cabbage. Of 13 varieties tested on mineral soil, the following yielded best: midseason: Bonanza, Greenback; late: Green Winter, Evergreen Ballhead, Houston Evergreen.

Influence of Plant Spacing on Head Weight and Yield of Cabbage

At St. John's, a plant-spacing trial with late cabbage showed that a 12-inch spacing produced heads with an average weight of 3 lb, whereas the 18-inch spacing gave an average head weight of 4 lb. Despite the decrease in head weight at the 12-inch spacing, yields per acre were increased by 11.5%.

Weed Control in Vegetables

Carrots—Chlorpropham, mixtures of chlorpropham and carbaryl, linuron, and prometryne were tested as preemergence treatments on peat (Colinet) and mineral soil (St. John's). Linuron at 1 lb/acre (active) and prometryne at 2 lb/acre (active) gave excellent weed control on mineral soil, but none of the treatments were satisfactory on peat.

Swede turnips—Preplanting soil treatments of trifluralin and Vernolate,[5] tested on mineral soil here, did not give satisfactory weed control.

Small Fruit Varieties

Raspberries—Of 16 varieties tested, Boyne and Trent gave the highest yields.

Effect of Spring Burning on Blueberry Land

In 1962 an experiment was started at the Avondale Blueberry Substation to study the effect that burning blueberry land had on yields, plant ecology, and soil organic matter. The treatments were: burn every second year; burn every third year; burn every fourth year; and no burning.

In 1967, yields for the various treatments were: 1 year after burning, 1,573 lb/acre; 2 years after burning, 544 lb/acre; 3 years after burning, 56 lb/acre; and no burning, 71 lb/acre. These results show that the highest yields are obtained 1 year after burning, and the yields decline in subsequent years. One noteworthy point is that the yield of the third crop from land that was burned every fourth year was not different from that obtained on land that was never burned. The long-term effects of burning will not become apparent until the experiment has been in progress for several more years.

Forage Crops

Seeding of rough land over natural vegetation without cultivation—Stands of Empire bird's-foot trefoil established with a roller seeder on natural vegetation on the Burin Peninsula in 1965 have developed into excellent swards, considering the density of native vegetation. Experimental seedings planted in mid-September, 1966, on scrubby, mineral, and drained peat soils, with a modified roller seeder designed to distribute lime, fertilizer, and seed simultaneously, established quite well. Limestone at 2 tons/acre and 6-12-12 at 600 lb/acre were applied.

From June 15 to 22 a mixture of LaSalle red clover and alsike clover was seeded into an established stand of predominantly reed canarygrass on peat soil. Limestone at 1 ton/acre and 5-10-30 plus 2% field trace elements (FTE) at 500 lb/acre were applied. Clover establishment

[5] Stauffer Chemical Co.

was good in some areas but patchy in others. On June 23 seedings of white clover and bird's-foot trefoil made on blanket peat failed completely, apparently owing to a severe drought immediately after the seeds germinated.

Timothy varieties—Two new varieties of timothy, Champ and Bounty, have been under test on mineral soil for a number of years. The ideal cutting dates ranged from July 12 for Champ to July 21 for Bounty, as compared with July 17 for Climax. The judicious use of these new varieties will be a great help to local stockmen in producing quality hay.

Corn fodder varieties—Selected corn hybrids have been tested for 3 years, 1965–1967, for possible use as silage on the Avalon Peninsula. Only in 1967 did any varieties reach a stage of maturity suitable for ensiling, though total dry matter production was excellent compared to alternative annual crops. In the 3 years of testing, Haapala 175, one of the better varieties, produced 54.8, 37.9, and 55.7 cwt dry matter per acre at moisture levels of 82.9, 86.1, and 72.8%. The total heat units (base 50 F) from the seeding date to harvest date (immediately after the first frost) for the respective seasons were 869, 912, and 1,355 degree-days. As a result of these tests and because the 1967 season was above average in heat units, it is unlikely that corn silage in the commonly accepted sense will be a suitable crop for eastern Newfoundland. The addition of a preservative in making silage makes possible the utilization of the fairly high dry-matter production of corn. The crop also contributes to weed control.

Cereals

Variety trials—Fundy oats and Gateway barley yielded 41.7 and 36.5 bu/acre on peat soil compared with 24.8 and 27.3 bu/acre on mineral soil in a dry year.

In general, the varietal responses of oats and barley were similar to those reported previously. The newly introduced Finnish oat variety, Pindec, under test for the second year, gave very good grain and straw yields on peat soil (54.8 bu/acre of grain and 22.8 cwt/acre of dry straw), but was lowest in bushel weight. It was generally poor on mineral soil.

ENTOMOLOGY

Cabbage Maggot

Twenty-one insecticide treatments and a control were established at St. John's and St. Davids for control of root maggots on swede turnips. Insecticides, at several rates, were applied as granules in the furrow, as granules in the furrow plus a postthinning drench, and as granules in the furrow plus two supplementary drenches. The most effective treatments in both localities were split applications of: fensulfothion, NIA 10242,[6] thionazin, and G.C. 4072.[7] Split applications of insecticides, granules at seeding and a drench after thinning, more effectively controlled root maggots than did single applications at seeding, and reduced phytotoxicity in both localities.

European Earwig

Recovery studies to determine the build-up of the parasites *Bigonicheta spinipennis* and *B. setipennis* were continued. Based on annual studies of 4,000 fourth-instar nymphs and adults, parasitism increased from 6.0% in 1966 to 8.2% in 1967. There has been a progressive buildup since 1964.

Blow Fly Control

Experiments were started to develop a control for blow flies that attack Spanish and Madeira grades of light, salted, sun-dried codfish. The species of blow flies were identified as *Lucilia illustris* (Meig.) and *Calliphora terraenovae* (Macq.). Of 10 insecticide treatments tested, pyrethrum at a concentration of 0.062% gave adequate protection and showed a remarkable repellancy to adult flies. Residues of pyrethrins in the fish 3 weeks after treatment were 0.19–0.26 ppm.

Biology and Behavior of the Golden Nematode

A 4-year rotation, swede turnips, oats, grass, potatoes, significantly decreased the golden nematode population, while a

[6] FMC Corporation Niagara Brand, Chemicals Division.
[7] Shell Canada Ltd.

potato monoculture caused a corresponding increase in number of viable cysts. A monoculture of grass–oats on the same soil, although depressing the population of the golden cyst nematode, *Heterodera rostochiensis* Woll., appreciably increased the population of the grass cyst nematode, *H. punctata* Thorne, and oat cyst nematode, *H. avenae* Woll.

Research on the dissemination of the golden cyst nematode by natural means showed that ingested cysts survived passage through the gastrointestinal tracts of pigs and rabbits and reinfested potatoes. Cysts were found also to be carried on high-velocity winds from an infested area. Therefore, air currents may spread the species.

A comparison of the function of soil water, water vapor, and dry air in carrying potato-root diffusate, which is needed to hatch eggs within the egg-engorged cyst of the golden nematode, showed that dry air, although less effective than water vapor or water, carried the diffusate in sufficient amounts to stimulate hatching markedly.

PLANT BREEDING AND PATHOLOGY

Potato Breeding for Resistance to Wart and Golden Nematode

Potato breeding was continued; 53 crosses were obtained in which at least one parent in every combination was highly resistant or immune to wart disease. *Solanum tuberosum* L. × *S. vernei* Bitt et Wittm. hybrids, which have high resistance to golden nematode and potato wart, were backcrossed to *S. tuberosum* or intercrossed among themselves to obtain progenies in which to study the segregation of resistance to golden nematode and wart disease.

Fifty-seven clonal lines from 16 tuber-bearing *Solanum* L. species have been increased in the greenhouse to obtain material to be screened for possible resistance to wart and golden nematode.

The completion of new greenhouses has made possible an increase in the production of potato seedlings, and about 13,000 have been grown for field planting in 1968. Approximately 950 single-hill selections were made from 10,150 clones produced in the greenhouse in 1966. Over 350 clones of *S. tuberosum* ssp. *andigena* (Juz. et Buk.) Hawkes. were grown in the field and a number of tuber-bearing selections were made for further evaluation.

The 1,124 hill selections made in 1966 and the 219 seedlings already grown for 1 or more years in adaptation trials were retested and screened for wart resistance at Avondale. Selections have been made for further testing or for inclusion in replicated yield trials. Evaluation of *S. tuberosum* × *S. vernei* hybrids for combined resistance to golden nematode and potato wart was continued and levels of resistance continued high.

Replicated Potato Yield Trials

Sixteen named varieties and 20 numbered selections developed here were compared in a replicated yield trial. Fifteen seedlings significantly outyielded Arran Victory, and one exceeded Kennebec in marketable yield. In total yield, Arran Victory and Kennebec were exceeded by 13 and 6 varieties respectively. Eight of the numbered selections will be retested in replicated trials at several locations in Newfoundland in 1968. All of these seedlings have high resistance to wart, and desirable tuber characteristics.

Replicated yield trials of four varieties and eight numbered selections were conducted at Doyles, Robinsons, Cormack, Lethbridge, and St. John's, Nfld. Two seedlings, SJ6226-9 and SJ6226-61, performed very well. In marketable yield, SJ6226-9 exceeded Kennebec at one location, equaled it at four, outyielded Arran Victory at three places, and equaled it at two. SJ6226-61 equaled Kennebec everywhere except at St. John's, outyielded Arran Victory at three locations, and equaled it at two. Both seedlings have smooth, uniform red-skinned tubers with high wart resistance. Evaluation of these seedlings as possible varieties will be continued in 1968.

Potato Plant Spacing Study

A replicated field trial was conducted to determine the optimum spacing for planting potato seedlings and varieties, which differ in number of tubers produced. Four named varieties and eight numbered seedlings were compared at 12- and 15-inch row spacings.

Disregarding spacing, varieties differed from each other in yields of total, marketable and cull potatoes, in numbers of total, marketable and cull tubers, in average weight of marketable tubers, and in percentage of marketable tubers. Marketable and total yields did not differ at the two spacings, but the percentage of marketable tubers was increased in the selections SJ6119-47, SJ6218-98, and SJ6226-9 by 15-inch spacing. At this spacing, the yield of culls was reduced in SJ6119-47 and SJ6226-9. Sebago, SJ6119-47, and SJ6226-9 were the only varieties that produced a greater total number of tubers at the 12-inch spacing than at 15 inches. The number of marketable tubers produced did not differ with spacings, but the number of culls was lower in Arran Victory, SJ6119-47, and SJ6226-9 at the 15-inch spacing than at 12 inches.

Effect of Dinoseb on Growth and Yield of Potatoes

The herbicide dinoseb has been found to control potato wart disease when applied as a preemergence spray and when incorporated with soil before planting. During 1967 a replicated trial was conducted to determine the effect of increasing rates of application on plant stand and yield in the absence of wart disease. Dinoseb at 0, 5, 10, 20, and 40 lb/acre was sprayed onto the plots and disced in. Potatoes were planted either on the day of application or 9 days later.

Plant stand was not affected by dinoseb at 5 and 10 lb/acre, but was reduced by applications of 20 and 40 lb/acre. Marketable and total yields were reduced only by applications of 40 lb/acre.

To determine the possible effect of dinoseb on available nutrients, soil samples for NPK analyses were collected from the control and treated plots, beginning the day before application and continuing at weekly intervals for 14 weeks.

All rates of application caused slight but nonsignificant reduction in available nitrate levels in the second and third week after application. Rate of nitrification then apparently improved and nitrate levels remained the same as in the control from the fourth week on. No effect on pH or on available phosphorus, potassium, or calcium was detected.

Breeding Swede Turnips for Clubroot Resistance

Turnip, *Brassica rapa* L. 'Gelria' and 'Novitas', was crossed with swede turnip, *B. campestris* var. *napobrassica* DC. 'York' and 'Wilhelmsburger', and the following crosses were obtained: York × Gelria, Wilhelmsburger × Novitas, Gelria × Wilhelmsburger, and Wilhelmsburger × Gelria.

Hybrid seed was sown in field plots heavily infested with clubroot, and Novitas, Gelria, York, and Wilhelmsburger were sown for checks. At harvest time, plants from all of the crosses segregated into roughly equal numbers of fully clubroot susceptible plants and plants in which a few of the fibrous roots had a nodule-type of clubroot infection. Roots of York and Wilhelmsburger were 100% susceptible, Gelria was 10% susceptible and 90% free, and Novitas was 100% free from infection. Roots from the cross Wilhelmsburger × Novitas had yellow flesh and all the others had white flesh. Flesh texture and flavor were intermediate between turnip and swede turnip.

Research

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Research Station
Charlottetown, Prince Edward Island

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INTRODUCTION

The functions of the Research Station, Charlottetown, are: to breed varieties of cereals suitable for production in the Atlantic Provinces; to develop efficient management practices for the production of tobacco, vegetable, cereal, and forage crops in the Atlantic Provinces including land preparation, seeding, fertilizing, disease and pest control, and harvesting; to improve the utilization of feed crops in animal nutrition and to cooperate in the national dairy cattle breeding project; and to devise disease control methods for potato crops in cooperation with the national potato breeding program. Although much of this research has regional objectives, results often have national or international significance. The research is not described in detail, but detailed accounts may be found in the publications listed at the end of this report, or may be obtained by writing to this station.

G. C. Russell
Director

CEREALS

Climatic Effect on Cereals, 1967

A cold wet spring, continuous warm humid weather throughout the growing season, and storms combined to produce the most unfavorable conditions on record for cereal production. Late seeding, severe disease attacks, floret sterility, early lodging, premature aging, and poor harvest weather were encountered. Yield and quality losses were high in all crops but particularly in barley.

The season did provide an opportunity to rate barley varieties and breeding stocks for reaction to severe natural infections of *Helminthosporium sativum* (Pamm., King & Bakke) and to floret sterility, which appeared to be related to hot humid weather during pollination. Two-rowed types generally exhibited much higher floret sterility (up to 50%) than six-rowed types, and selection within types was possible. The unnatural conditions for growth and the effects of storms prevented good comparisons of resistance to lodging in both oats and barley. Premature aging ranged from 10 to 20 days and was attributed primarily to *Helminthosporium sativum, Septoria avenae* Frank, and *Fusarium* spp. on barley, oats, and wheat, respectively.

Critical Nutrient Levels in Barley Tissue

In a greenhouse experiment where Herta barley was grown in two 6 × 6 factorial experiments on low P and low K soil, final grain yields for different rates of N, P, and K fertilization were related to the percentage of N, P, and K in tissue sampled at the boot stage. The minimum levels in tissue below which final grain yields were severely restricted were 1.00% N, 0.25% P, and 1.00% K. Although maximum yields were not attained in this experiment, values for each nutrient in tissue at the highest yields obtained were 1.40% N, 0.30% P, and 1.50% K. When sampled at the early vegetative stage, values in tissue below 0.60% for P and 5.75% for K restricted final grain yield. Utilization of N by the barley plant for increased grain yields was dependent on adequate levels of P and K in the tissue.

Nitrogen Source Important for Early Barley Growth

An experiment in which Herta and Charlottetown 80 barley were grown in nutrient solution culture in the greenhouse showed that NO_3^- was a better source of nitrogen than was NH_4^+ for early vegetative growth. Yields with 100% NO_3^- or 50% NO_3^- + 50% NH_4^+ were two to three times higher than those obtained with 100% NH_4^+. The ammonium source was toxic at the high N (100 ppm) concentration in combination with the low P and K (10 ppm) concentrations. Adequate P and K were required for utilization of either source of N because utilization was two to three times greater with the high (100 ppm) rates of P and K than with

the low (10 ppm) rates. Herta appeared to be more susceptible than Charlottetown 80 to NH_4^+ toxicity and K deficiency in the early growth stages.

Selection of Barley for Reaction to Aluminum

Studies were started to develop a technique suitable for determining the reaction of individual barley plants to Al ions. Plants from 15 varieties were grown in nutrient solution containing nine different concentrations of active Al. Measurements of root development and dry weights of roots and tops indicated that, with slight modification, the technique will provide sufficient uniformity for selection in segregating populations during the early vegetative stage.

POTATOES

Potato Fertility Studies

An experiment was conducted on a Charlottetown fine sandy loam for 8 years to determine the effect of varying levels of N, P, K, and manure on the yield and starch content of potatoes. Factorial combinations of N at 90, 135, and 180 lb/acre; P at 80, 105, and 130 lb/acre; and K at 140, 210, and 280 lb/acre were applied broadcast as subplots in a split plot design with 0 and 10 tons of manure. A 4-year rotation of potatoes, oats, clover, and timothy hay was followed; each crop was grown every year.

Manure increased the yield of marketable potatoes by 63.0 and 66.9 bu/acre in the first and second cycles of the rotation. There were no significant manure × fertilizer interactions. Broadcast applications of 135 lb/acre of N, 80 lb/acre of P, and 210 lb/acre of K, applied either alone or with manure, resulted in maximum economic production. Increases in the levels of N and P had no significant effect on the starch content of potatoes. At the 210 lb/acre level of K the starch content was only 0.35% lower than it was at the 140 lb/acre level.

Potato Varietal Susceptibility to Fusarium and Phoma Storage Decays

Nineteen potato varieties were screened at Charlottetown in 1967 for resistance to tuber decay caused by *Fusarium sambucinum* Fckl. f.6 Wr., and *F. coeruleum* (Lib.) Sacc. High susceptibility to *F. sambucinum* f.6 was noted in the Sebago and Keswick varieties and in Fredericton seedlings F6142, F5646, and F5929. Hunter, Irish Cobbler, and Red LaSoda were highly resistant to this type of decay.

Fredericton seedlings F5317, F5933, F6124, F6142, F5646, F5552 proved to be highly susceptible to decay caused by *F. coeruleum* and were equivalent in this respect to known susceptibility shown in the variety Hunter. The widely grown commercial varieties Irish Cobbler, Sebago, and Kennebec proved to be resistant to this type of decay.

High susceptibility to "pocket rot" caused by *Phoma tuberosa* Melhus, Rosenb. & Schultz was noted in F6142 and in the varieties Grand Falls and Sebago. Commercial losses due to phoma decay have been largely confined to the variety Sebago.

Potato Varietal Susceptibility to Verticillium Wilt

Twenty-four potato varieties and seedlings were tested in 1967 for susceptibility to wilt caused by *Verticillium albo-atrum* Reinke & Berth. Two Fredericton seedlings, F6110 and F6119, showed no foliage symptoms, whereas in the variety Kennebec, 72.5% of plants developed symptoms. The variety Norgold Russet, which was granted a temporary Canadian license in 1967, proved to be highly susceptible to wilt. Similar high susceptibility was encountered in initial testing of the variety Superior.

Seed Treatment Control of Fusarium and Verticillium Diseases

Effective control of potato seed-piece decay caused by *F. coeruleum* was obtained by treating surface-contaminated seed with Polyram 7 Dust. Treatment resulted in a superior stand and more vig-

orous plants. Tuber yields were substantially increased in Polyram-treated plots. Only partial control of verticillium wilt was achieved with this dust treatment.

Late Blight of Potatoes

The wet and humid season of 1967 made it possible to evaluate fungicides entered in the national screening test under extremely severe disease conditions. In descending order of merit, the best control of foliage blight was provided by mancozeb, RH-90, Difolatan Flowable, Organil 66, and Difolatan 80W. Four fungicides containing triphenyltin chemicals were less efficient, but showed no visible phytotoxic action under the weather conditions that prevailed in 1967. Plots treated with the Difolatans had the smallest percentages of loss from tuber rot, a phenomenon that was also observed in two previous seasons in which late blight attacks were severe.

Potato Top Killing

Potato top killers containing sodium arsenite continue to be the most popular among growers in the province, even though their use carries the danger of livestock poisoning. Equally good kills of the tops were obtained with diquat and paraquat, each used at 2.2 kg/ha (1 qt/acre), but at double or more the cost of sodium arsenite products. Tests have shown that comparable killing actions may be secured and costs reduced by applying a spray containing 1.1 kg/ha (1 pint/acre) of either diquat or paraquat and fuel oil at 17.6 kg/ha (2 gal/acre).

Straight Versus Split Potato Spray Schedules

The data from several years of studying straight and split schedules for spraying potatoes have shown that plots treated with maneb gave the highest yield, the lowest percentage of small tubers, and the highest percentage of late blight tuber rot. Plots sprayed with bordeaux mixture gave the lowest yield, the highest percentage of small tubers, and the lowest percentage of rot. The split schedule of maneb in the first half of the season and Bordeaux in the second half was intermediate to the straight schedules in all three respects. Tuber specific gravity readings, taken in the last 3 years, indicated that the split schedule may be expected to occupy the intermediate position in this respect as well, tubers from Bordeaux and maneb plots having the highest and lowest specific gravities respectively.

Potato Insect Control

Sprays—In experimental plots at Charlottetown, 15 compounds were under test, and about half of them were effective for controlling the main potato pests, including aphids, flea beetles, and Colorado potato beetles. Fensulfothion emulsifiable concentrate (E.C.) at 1.1 kg of toxicant per ha (1 pint/acre) was the most effective, followed by C-9491 wettable powder (W.P.) at 1.1 kg, C-8874 E.C. at 1.1 kg, endosulfan E.C. at 2.2 kg, diazinon E.C. at 1.1 kg, and Imidan W.P. at 2.2 kg of toxicant per ha.

Soil treatments with systemic insecticides—Systemic insecticides applied to the soil just before planting were more effective in 1967 than in the 2 previous years. The 1967 growing season was wetter than the 1965 and 1966 seasons, and it appears that soil applications of these materials are more effective under high moisture conditions. Temik 10% granular (10G) at 22.4 kg/ha (20 lb/acre) was the most efficient material for controlling aphids, flea beetles, and the Colorado potato beetle. NIA 10242 10G at 33.6 kg, disulfoton 10G and fensulfothion 10G each at 22.4 kg, and phorate 10G and disulfoton 10G each at 11.2 kg of toxicant per hectare also gave good results.

FORAGE CROPS

Effects of Clover Root Curculios and *Fusarium* spp. on Red Clover

The results of two greenhouse experiments indicated a relationship between root injury caused by the clover root curculio, *Sitona hispidula* (F.), and the incidence of root decay of red clover. Most decay developed and a greater proportion

of root sections yielded *Fusarium* spp. when clover root weevils were present with *Fusarium* spp.

Release of Cinnabar Moth on Tansy Ragwort in P.E.I.

The cinnabar moth, *Hypocrita jacobaeae* (L.), one of the primary natural controls of tansy ragwort, was first introduced into Prince Edward Island in 1964. It did not survive the winter, probably because of heavy predation of the overwintering pupae by mice and carabid beetles. Further releases were made in 1965, 1966, and 1967. The insect survived two winters in one location, and one winter in another location, evidence that there is a good chance for establishment of this beneficial insect in Prince Edward Island. This form of control may not completely eliminate tansy ragwort, but should maintain control to the point where the plant no longer causes economic stress.

Clover Root Borer in the Maritimes

The clover root borer, *Hylastinus obscurus* Marsham, is one of the principal agents limiting the life of a red clover stand, particularly after the 1st crop year. Until recently, it was believed that the borer was not present in the Maritime region. Root borers and root borer damage were found for the first time in 1st-year red clover root samples taken from a field near Truro, N.S., in July 1966. Later the pest was found in fields near Moncton and Petitcodiac, N.B. The borer has not been found in Prince Edward Island. In view of these findings, observations will continue so that the possible buildup and spread of this pest may be followed.

Sclerotinia Crown Rot of Forage Legumes

The effect of 29 sources of N, representing both organic and inorganic forms, on the growth of two isolates each of *Sclerotinia trifoliorum* Erikss. and *S. sclerotiorum* (Lib.) de Bary was studied in the laboratory. Good sources of N were: casein hydrolysate, L-proline, DL-asparagine, L-arginine, L-glutamic acid, L-aspartic acid, L-histadine, L-alanine, NH_4Cl, NH_4NO_3, L-tryptophan, $(NH_4)_2SO_4$, and DL-phenylalanine. Growth by the *S. trifoliorum* isolates on the ammonium nitrogen sources was significantly better than on the nitrate sources. No such difference was observed for the *S. sclerotiorum* isolates. Concentrations and incubation periods affected the results significantly.

Root-lesion Nematode Development and Its Effect on Growth of Forage Legumes

Greenhouse experiments were conducted in which four levels of infestation of the root-lesion nematode *Pratylenchus* spp. (0, 25, 250, and 2,500 nematodes per plant) were compared on four forage legumes (red clover, white clover, alfalfa, and birdsfoot trefoil). With the exception of white clover, forage yields of all species were significantly reduced by the highest level of infestation. Percentage reductions in yield at the highest infestation level compared with the 0 level were 9, 22, and 45 for alfalfa, red clover, and birdsfoot trefoil respectively. The nematodes reproduced well in all species.

Forage Legume Food Preferences of the Clover Root Curculio

Feeding preferences of larvae and adults of the clover root curculio, for five commonly grown forage legumes (alfalfa, birdsfoot trefoil, red clover, alsike clover, and white clover) were studied in the greenhouse. In descending order, the feeding preferences of adults for the foliage were white clover, alsike clover, red clover, alfalfa, and birdsfoot trefoil. Feeding preferences of the larvae for the roots were red clover, white clover, alsike clover, alfalfa, and birdsfoot trefoil. Larval survival appeared to be best in the presence of white clover.

Potassium Requirements and Management of Alfalfa

Adequate K fertilization and proper cutting management are essential for high production and winter survival of alfalfa. Studies conducted on two soil types over a 4-year period showed little increase in yields of alfalfa with annual applications of K above the 100 lb/acre level, when the available P content of the soil was adequate. When the entire K treatment was made in the early spring, yields of hay were generally higher than when the K was applied in split treatments. No ap-

parent advantage with respect to seasonal production or winter survival of the crop resulted from applying split treatments of K. The annual application of only 50 lb/acre K, in single or split treatments, resulted in reduced yields of alfalfa and poor winter survival.

Alfalfa survived best under one cutting treatment per season, but annual production was somewhat lower than where two cuttings were made. Highest dry-matter yields were obtained when the first cutting was made just before the 50% stage of bloom and the second cutting at the 10% stage of bloom.

Regrowth Potential of Perennial Forage Crops

Triphenyltetrazolium chloride (TTC), which has been used to estimate the ability of seeds to germinate, was used to evaluate the viability of alfalfa, birdsfoot trefoil, timothy, and bromegrass plants. The method is based on the principle that hydrogenesis of the colorless TTC to a deep red triphenylformazan in the meristematic tissue of the storage organ indicates viable buds capable of regrowth. The active growing points on the crowns of legumes, on the nodes of timothy haplocorm, and on the rhizome tips of bromegrass showed red color following incubation with TTC solution, whereas the tissues injured or killed by cold treatments were less stained or not stained. This technique makes possible a visual evaluation of the regrowth potential of forage species and can be modified to provide a quantitative estimate of regrowth potential.

Food Reserves in Timothy Haplocorm

Analysis of timothy haplocorm showed that the water-soluble carbohydrate fraction, the main food reserve, consisted of fructosans (64%), sucrose (12%), glucose (6%), and fructose (18%). A gel filtration using a Sephadex column was satisfactory for isolating fructosan from other sugars. Investigations with molecular sieving, paper chromatography, infrared spectrophotometry, and polarimetry disclosed that the fructosan consisted of 76 fructosyl groups attached through 2,6 linkages terminated by a sucrose molecule. Acid hydrolysis experiments showed that fructosan was more labile than starch, a major food reserve of forage legumes.

Metabolism of Fructosan in the Timothy Plant

The biosynthetic route of fructosan from CO_2 in the air was traced with C^{14} isotope. $C^{14}O_2$ was incorporated photosynthetically for 1 min into a timothy leaf blade, and then the tissues of leaf blade, leaf sheath, and haplocorm were analyzed separately. Within the first 5 min after treatment, sucrose, glucose, fructose, and fructosans were labeled with C^{14}. Although the C^{14} sucrose moved down to the haplocorm via the leaf sheath in 30 min after the incorporation, the C^{14} fructosans remained in the leaf blade. It was concluded that fructosan in the haplocorm was synthesized from sucrose translocated from leaves.

CRUCIFERS AND OTHER VEGETABLES

Clubroot Disease of Rutabagas

At Charlottetown, inheritance studies were conducted on nodular clubroot infection in rutabagas. This restricted manifestation of the disease is confined chiefly to the secondary roots. Experiments were carried out under exposure to race 2 of the pathogen using progeny from crosses of two rutabaga varieties, both resistant to unrestricted race 2 infection. Nodular-resistant green-top Wilhelmsburger was crossed with nodular-susceptible purple-top York, and the F_2 progeny from selfed hybrids was exposed to infection. Root populations segregated in the ratio of four nodular-resistant to one nodular-susceptible, indicating that resistance to nodulation is probably controlled by a single dominant gene. This ratio was maintained irrespective of root color in the F_2 progeny, indicating that the factor for root color is not linked with the factor for nodulation resistance.

Chemical Control of the Cabbage Maggot in Rutabagas

In randomized block experiments, NIA 10242 at 5.6 kg of toxicant per hectare (5 lb/acre) eliminated infestations of the cabbage maggot; and fensulfothion, thionazin, EI 47031, Bay 37289, and Birlane (G.C. 4072) at 5.6 kg gave 95 to 99% reduction of infestations compared with untreated plots. Phorate at 9 kg and the above materials at 3.4 kg gave 85 to 94% control. Mecarbam and diazinon 14G at 5.6 kg provided about 75% control, and phorate at 5.6 kg and diazinon at 3.4 kg, 50 to 60% protection. Tartan at 3.4 kg and at 5.6 kg, and heptachlor at 5.6 and 11.2 kg, gave no protection against maggot injury. Birlane is now registered and will be recommended for commercial use in 1968; fensulfothion, thionazin, and phorate were recommended in 1967.

Degradation of Organophosphorus Compounds in Soils as Measured by Bioassay

With first-instar larvae of the cabbage maggot, it is possible to measure concentrations of less than 1 ppm of phorate, thionazin, and fensulfothion or their residues in the soil. Recommended field applications place about 125 ppm of pesticide in the top 3.75 cm (1.5 inches) of soil with a band-in-row treatment, and when this rate of application was added to a sandy soil kept in the greenhouse at 12 to 21 C, residues in the range of 10 ppm of toxic components of fensulfothion remained in the soil after 1 year. Thionazin residues at the 10 ppm level were still found after 8 months, and phorate degraded to this level in 4 to 6 months.

Preliminary investigations in field plots with sandy, fine sandy loam, and clay loam soils at different pH levels have shown that fensulfothion retains its toxicity longer than the other materials, with 10 to 30 ppm remaining after 5 months. The studies are continuing with maggot-free soil, and 15,000 to 20,000 larvae are being used each week to determine residues in soil samples collected at intervals during the summer.

Diapause in the Cabbage Maggot

The pupal stage of diapausing cabbage maggots was subdivided into six developmental stages when it was discovered that environmental conditions affected the pupae differently as the insect transformed from mature larvae to adult. The stages and the shortest period of time taken for development at optimum temperatures and soil moistures include (i) formation of puparium, about 1 day at 21 C; (ii) prepupal development, 2 days at 21 C; (iii) pupal development, 9 to 12 hr at 21 C; (iv) diapause development, 3 to 6 months at 5 C; (v) growth development, 6 to 7 days at 21 C (arrested at temperatures above about 22 C); and (vi) adult development (transformation from pupa to adult), 4 days at 27 C. In the diapause stage (iv), development occurs up to a temperature of 27.5 C; mortality is high if temperature is above 22 C during the whole period, but no mortality occurs if the high temperature is employed only during the last 30 to 40 days of diapause development.

All stages proceed to completion at temperatures ranging from 5 to 20 C, requiring about a year at 5 C and 4 to 6 months at 20 C. Nondiapausing pupae progress to the adult stage in about 12 to 16 days, and length of the various stages is influenced by temperature.

Broccoli, Single Harvesting

In keeping with the current trend toward the mechanical harvesting of vegetable crops, a preliminary experiment was conducted in which broccoli was seeded at various spacings and single harvested. Mean head weight decreased as plant density increased, but the total marketable yield was affected only slightly by plant spacing. Yields from single-harvested, high-population plantings were almost as high as yields from plantings that had conventional spacings and required five to eight cuttings per season.

Effect of Nitrogen, Phosphorus, Potassium, and Manure on Yield of Broccoli

A factorial experiment was conducted during three successive cropping seasons to investigate the effects of N, P, K, and manure on the growth and yield of broc-

coli. The N and P applications increased terminal head weight and total marketable yields. K applications had little effect on yields. Yield increases from high rates of N were obtained only when accompanied by adequate P. Manure increased yields in two of the three trials.

Response of Brussels Sprouts to Phosphorus Placement in Greenhouse Pots

Banding of P at 25 ppm 3 cm below and 4 cm to the side of Brussels sprouts seed increased total plant dry-matter yields 58% above check yields. Mixing 50 ppm P through the soil increased yields 63% above the check. A combination of 25 ppm P banded and 50 ppm mixed through the soil gave 80% increase in yield. Banded P became relatively more effective than P mixed through the soil as soil pH decreased from 6.5 to 5.0.

Influence of Phosphorus on Molybdenum Content of Brussels Sprouts

Application of P at rates up to 175 lb/acre decreased the molybdenum content of the dried leaf tissue from 0.66 to 0.38 ppm in the field and from 0.36 to 0.22 ppm under greenhouse conditions. The results indicated that one must be more conscious of Mo deficiency with the higher fertilization rates now being used. Plants grown under moist conditions contained more molybdenum than those grown under drier conditions.

Correlation of Cole Crop Yields and Tissue Analysis with Soil Fertility Levels

Brussels sprouts have been grown on soils of different fertility status, and the yields and tissue nutrient contents are being related to soil analysis values. Enough information will soon be available on which to base fertilizer recommendations suitable to specific soil conditions as determined by soil analysis. Brussels sprouts have responded to N and P on soils of the region which are in the medium to high fertility range. Response to K occurred only on soils of very low fertility.

Snap Beans, Greater Yields

Field trials conducted during three consecutive cropping seasons indicated that yields of green beans may be increased by high seeding rates. The variety Tendercrop was seeded in rows spaced 30 inches apart with in-row spacings of 1, 2, 3, and 4 inches. Total yields increased as the distance between seeds decreased in all years and the effect was linear for the treatments employed in these experiments. Size distribution of the harvested beans was not affected by seed spacing.

Weed Control in Spinach

A number of herbicides have been tested individually and in combinations during the past 5 years. Pyramin and ramrod have substantially reduced the populations of a number of broad-leaved weeds and generally have not reduced crop yield. Ramrod did not control chickweed in one trial. Herban, tested for the first time in 1967, also appears promising.

Vegetable Variety Trials

A number of varieties of peas, broccoli, and cauliflower were evaluated. Sparkle pea appears promising as a dwarf, early maturing variety for freezing. F_1 hybrid 47 broccoli has been added to the list of recommended varieties. It is large, early, and very productive. A number of cauliflower varieties performed well, including Snowball X, Snowball Y, Takii 2, Takii 3, Mt. Hood, Snowball Imperial, Whitehorse, Snowball 25, Snowball 84, Snowking, and Perfected Snowball. Complete reports of these trials are available.

SOIL SCIENCE

A Simplified Method for Determining Hot-water-soluble Boron in Podzol Soils

Measuring the amount of available boron has been the accepted method for detecting a deficiency of boron in soils. However, the available procedures were laborious and time-consuming. Therefore a procedure was developed whereby the

filtrate obtained after boiling the soil with water was directly analyzed using carmine as the color-developing reagent. This procedure is free of interferences from organic matter and nitrates, and is recommended for accurate determination of available boron in podzol and perhaps other soils.

Response of Some Crops Grown on P.E.I. Soils to Applied Molybdenum and Copper

Alfalfa and Hudson barley were tested in a greenhouse experiment to determine their copper requirement. As with the two previous crop species discussed in the 1965–66 research report, copper did not increase the yield of these two crops. It appears that most of the soils of Prince Edward Island are sufficient in their copper content and do not require any additional copper fertilization. Without added molybdenum, all the tested crops (spinach, barley, cauliflower, timothy, and alfalfa) were almost a complete failure on all the tested soils. This indicates that most of the Island soils are too low in molybdenum to supply plant requirements.

Effect of Plant Species on the Amino Acid Content and Nitrification of Soil Organic Matter

The total amount of amino compounds was much higher in soil that had grown alfalfa for 7 years than in soil growing corn or bromegrass for 7 years. Incubation of soils indicated that alfalfa plots produced the largest amounts of nitrate nitrogen. Of the total soil nitrogen, 2.9 to 4.6% was accounted for in the form of nitrates over a 9-week period. No nitrates were produced beyond an incubation period of 9 weeks. This partly explains the need for supplemental fertilizer nitrogen for long-season crops. The results also indicated that a large percentage of amino nitrogen in soil is not readily nitrifiable.

Soluble Aluminum Restricts Root Development

The presence of Al in soluble form in acid soils of low pH not only reduces the chances of establishment of legume and other seedlings, but also restricts the penetration of roots into acid subsoil, thereby rendering plants more susceptible to drought. Twenty-five samples of Prince Edward Island soils having a pH of 5.6 or below were analyzed to determine their Al content. Concentrations of water-soluble aluminum at pH 4.5 ranged from 2.5 to 3.8 ppm, whereas at pH 5.0, it ranged from 0.2 to 3.0 ppm. Fertilization of soil at pH levels below 5.0 doubled the concentration of soluble aluminum. These concentrations exceeded the levels of soluble aluminum previously shown to restrict growth of legumes and of some varieties of barley. Soluble aluminum also occurred in the subsoil. Analyses of subsoils that had a pH of 5.0 or lower showed that aluminum did occur in concentrations that could restrict root development of many agronomic crops.

TOBACCO

Evaluating Inorganic Components of Flue-cured Tobacco by Uncured Leaf Samples

Cured and uncured leaf samples of flue-cured tobacco from plots that received six rates of dolomitic limestone at six locations over a 3-year period were analyzed for K, Ca, and Mg. Average cation percentages of cured samples were greater than those in uncured samples by a factor of 1.23, and the two sets of data were highly correlated. Treatments or locations had no appreciable effect on the ratio of cured to uncured cation content, and the precision of variance analyses was comparable for both sets of data. It was concluded that analysis of uncured tobacco leaves can be used to predict the inorganic composition of the cured product.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Bay 37289	Chemagro Corporation
Baygon	Chemagro Corporation
Birlane (G.C. 4072)	Shell Canada Limited
C-8874	CIBA Company Limited
C-9491	CIBA Company Limited
Difolatan	Chevron Chemical (Canada) Limited
EI 47031	American Cyanamid Company Limited
Herban	Green Cross Products
Imidan	Stauffer Chemical Company
NIA 10242	Niagara Brand Chemicals
Organil 66	Procida, Neuilly sur Seine
Polyram 7 Dust	Niagara Brand Chemicals
Pyramin	Niagara Brand Chemicals
Ramrod	Monsanto
RH-90	Rohm and Haas Company (Canada) Limited
Temik	Union Carbide (Canada) Limited

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Research Station
Kentville, Nova Scotia

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F. T. Lord, B.S.A., M.Sc.	Ecology of insect predators
C. R. MacLellan, M.C., B.Sc. (Agr.), M.A.	Ecology of the codling moth
W. T. A. Neilson, B.Sc., M.Sc.	Apple maggot investigations
K. H. Sanford, B.Sc. (Agr.), M.Sc.	Integrated control
H. B. Specht, B.Sc. (Agr.), M.S., Ph.D.	Apple aphids

[1] Duty transfer to Research Branch, Ottawa, July 1967, Acting Assistant Director General (Eastern).
[2] Acting Director, July 1967, from Ottawa Research Station.
[3] Appointed May 15, 1967. On educational leave 1967-68.

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R. G. Ross, D.F.C., B.Sc. (Agr.), M.Sc., Ph.D.	Head of Section Tree fruit diseases
T. Curren, B.Sc., M.A., Ph.D.	Physiology of storage diseases
C. O. Gourley, B.Sc. (Agr.)	Vegetable and small fruit diseases
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G. G. Smeltzer, B.Sc. (Agr.)	Forage and pasture crops

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F. W. Calder, B.Sc. (Agr.), M.S.	Pastures and forage physiology
H. M. Cunningham, B.S.A., M.Sc., Ph.D.	Pig nutrition
L. P. Jackson, B.Sc. (Agr.), M.S.	Soil fertility and crop management
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Departures

D. W. Friend, B.Sc., M.Sc., Ph.D. Transferred to Research Station, Fredericton, N.B., September 1967	Pig nutrition
T. Fuleki, B.Sc., M.Sc., Ph.D. Transferred to Department of National Health and Welfare, Ottawa, July 1967	Fruit juices and fermentation
R. P. Jaques, B.S.A., M.S.A., Ph.D. Transferred to Research Station, Harrow, Ont., June 1967	Insect pathology
H. T. Stultz, B.A., M.Sc. Retired November 1967	Bionomics of fruit insects
D. F. Wood, B.Sc. (Agr.), M.Sc. Resigned May 1967	Food processing

INTRODUCTION

This report presents the main findings of the research programs at the Research Station, Kentville, and the Experimental Farm, Nappan, for 1967.

Space limitation prevents giving details of experiments, and generally only the results of completed research are reported.

The Kentville Station has responsibility for horticultural and poultry research in the Atlantic region. Main emphasis is on production efficiency of available cultivars and breeds by developing superior cultural practices. Research on genetics, mating systems, and applied breeding is conducted to develop superior cultivars and strains. Cultivar evaluation and adaptation with forage and cereal crops for western Nova Scotia is carried out. The plant research program is supported by specialists in entomology, plant pathology, plant physiology, and chemistry.

The Experimental Farm at Nappan continued research on the production of cereal and forage crops and on the nutrition and management of livestock. Development of procedures for preserving forage as hay or silage is important and research on crop production on dike land is carried out.

L. P. S. Spangelo
Acting Director

NUTRITION AND CULTURE OF CROPS

Lowbush Blueberry

In a greenhouse sand-culture experiment, ammonium nitrogen or ammonium nitrogen and nitrate nitrogen produced better growth than nitrate nitrogen alone. The form of nitrogen also affected the nutrient levels in the leaves. The plants that received ammonium nitrogen had higher leaf N, P, and Fe and lower K, Ca, Mg, Mn, and Al than the plants that received nitrate nitrogen.

Pollen germination was inhibited in artificial media containing ziram or ferbam and to a much lesser extent in media containing zineb. Germination of pollen from plants dusted with the fungicides was not affected. The germination of pollen mixed with any one of the fungicides was inhibited if held under wet conditions, but under dry conditions only ferbam and ziram caused inhibition.

Pollinated flowers of lowbush blueberry produced more ethylene than nonpollinated flowers. Flowers floated on water or IAA also produced more ethylene than controls.

Strawberry

The highest yield and runner production of Redcoat strawberry was obtained from treatments supplying calcium at 240 ppm and phosphorus at 50 ppm in a sand-culture experiment in a greenhouse. The firmest fruit was obtained with calcium at 160 ppm and phosphorus at 20 ppm.

The effect of form and level of nitrogen supplied to Acadia strawberries in a sand-culture experiment in a greenhouse was influenced by the pH of the growth medium. Two milliequivalents of NH_4 plus 2 meq of NO_3 nitrogen at pH 5.5 caused a growth response similar to 6 milliequivalents of NO_3 nitrogen. The plants that received NO_3 nitrogen grew more vigorously, were less flaccid, and less susceptible to mildew than those that received NH_4 and NO_3 nitrogen. The plants that received both forms of nitrogen together had in their tissues more total soluble nitrogen, higher levels of insoluble nitrogen and amino acids, more NH_4 and less NO_3 nitrogen, higher levels of leaf and root nitrogen and phosphorus, and lower levels of leaf and root calcium and magnesium than those that received only NO_3 nitrogen.

Potatoes

Tuber yields on plots that received no phosphorus fertilizer ranged from 50 to 95% of those obtained with optimum phosphorus fertilization in field experiments conducted at 18 locations over a 3-year period. Each of three chemical methods used to estimate available soil phosphorus showed a wide range of values at different locations. However, when soils were grouped on the basis of available P as high, medium, and low, the response to applied phosphorus was much less on the high than on the medium or low classes.

Seeding Barley on Frozen Soil

Herta barley seeded on frozen soil in April yielded 54 bu/acre compared with 36 bu from seeding made on June 9. The early seeded barley produced an average of 23 kernels per head, the June 9 seeding only 17 kernels.

Alfalfa Rooting in Acid Soil

Investigation into the effect of soil acidity and soluble aluminum supports the conclusion that deep rooting of alfalfa is prevented by acid subsoil. The penetration of roots was investigated to a depth of 30 inches through five unlimed (pH less than 4.5) or limed (pH greater than 6.0) soil layers. Alfalfa taproots grew into all limed layers, but did not enter the unlimed soil below the depth of plowing. Only short, fibrous branching roots grew in the unlimed surface layer.

PROTECTION OF CROPS AGAINST PESTS

Biology and Integrated Control

The parasite *Allotropa utilis* (Mues.) was shown to be an important cause of mortality of apple mealybug, *Phenacoccus aceris* (Signoret). Predation and an unidentified fungus disease also accounted for some mortality. Egg and nymph losses from all causes were 90% in one test orchard.

In a laboratory experiment the mortality of eggs of winter moth, *Operophtera brumata* (Linnaeus), a new introduction to North America and a serious apple pest in Nova Scotia, was increased by lengthening exposure to temperatures in the range −26 to −34 F. The mean freezing point of winter moth eggs was found to be −31 F.

Animert V-101,[5] ovex, tetradifon, and chlorbenside were found to be largely innocuous to predaceous mites and predaceous insects. Dicofol was more detrimental to mites and about equal to the other compounds in its effect on insects. The results were obtained over a 2-year period in short-term tests in commercial apple orchards.

[5] Green Cross Products Division of the Sherwin-Williams Company of Canada.

Insect Pathology

The nematode DD136 was ineffective against larvae of the winter moth in an orchard test. In a laboratory test the nematode caused high mortality to the larvae of winter moth, fall cankerworm, *Alsophila pometaria* (Harris), fall webworm, *Hyphantria cunea* (Drury), eastern tent caterpillar, *Malacosoma americanum* (Fabricius), and pale apple leafroller, *Pseudexentera mali* Freeman.

In tests made in the fields, greenhouse, and laboratory, deposits of polyhedra of the nuclear polyhedrosis virus of the cabbage looper, *Trichoplusia ni* (Hübner), were found to be noninfective after 1 month exposure to weather. Inactivation by sunlight appeared to be a more important influence than washing away by rain. The virus was readily inactivated by exposure to ultraviolet light. In the other tests soil treated with 6.4×10^{10} polyhedra/m^2 retained 25% of the original infective virus after 5 years. Cruciferous plants were readily contaminated by the virus.

Miscellaneous Insects

Springtails of the suborder Anthropleona in grassland soil were reduced by aldrin, dieldrin, or heptachlor at 6 lb/acre in the year of application, but not in subsequent years. Springtails increased in the year of application of DDT at 3 lb/acre. Nine years after application of aldrin at 6 lb/acre, lindane at 1.5 lb, or chlordane at 10 lb, the numbers of springtails and mites were not changed.

Plant Diseases

The growth of *Gloeosporium album* in a liquid medium was reduced when the concentration of O_2 in the atmosphere was decreased. The addition of CO_2 to the low O_2 concentration stimulated the growth of the fungus to equal that of controls grown in air. The opposite effect was observed when the fungus was growing on apples where the addition of CO_2 to the atmosphere retarded the development of rots caused by *G. album* sp. and where, in the absence of CO_2, increasing concentrations of O_2 from 5 to 15% resulted in an increase in the rots.

Growth of *Typhula* sp., a fungus pathogenic to stored strawberry plants, was retarded by concentrations of 5 to 10% CO_2 and 5% O_2 in the storage atmosphere.

Pesticide Residues

Lead accumulation has resulted from foliar sprays of lead arsenate that were applied in the past to control insects. Total lead in a range of 7 to 360 ppm was found in soil samples taken to a depth of 15.2 cm in 19 apple orchards in Nova Scotia.

Weed Control

Lowbush blueberry—Blueberries have shown considerable tolerance for simazine at 4 lb, for dichlobenil, granular or spray, at 2 and 4 lb, and for Sinbar[6] at 0.5 and 1 lb/acre. These herbicides have all given satisfactory grass control, but simazine has reduced the growth of other weeds. Picloram, dicamba, 2,4-D, and amitrole were effective in controlling the growth of woody weeds and herbaceous perennials, but they also reduced the growth of blueberry plants.

Strawberry—Simazine at 4 lb/acre applied in two applications of 2 lb each in the season of planting strawberries gave weed control in the planting year and in the two subsequent cropping seasons. Eight varieties were included in the tests with simazine. Diphenamid and granular dinoseb applied in the year of planting gave weed control that lasted into the first but not the second crop year. These tests were carried on over 9 years, and 15 herbicides and combinations were evaluated.

STORAGE

Controlling Ethylene Levels in Apple Storage

The level of ethylene in small controlled-atmosphere containers of apples was controlled successfully by the addition of an ethylene absorbent to the CO_2 absorbent in the containers. Lime with $KMnO_4$ gave satisfactory results when the required CO_2 level was zero, but Celite

[6] Dupont of Canada Ltd.

alone gave better results when the required CO_2 level was in the 3–5% range. Silver nitrate plus H_2SO_4 was not satisfactory as an ethylene absorbent. It is dangerous to handle and caused dehydration of the apples in the container.

Postharvest Anaerobiosis of Fruit

Holding apples in atmospheres free of O_2 and CO_2 for 1 week before storage in conventional controlled-atmosphere gas mixtures reduced softening, rot development, and scald. The treatment increased core browning of apples stored in certain gas mixtures. Red Delicious, McIntosh, and Wagener varieties were tested with four different gas mixtures over four successive seasons. The O_2–CO_2-free atmospheres were maintained for 1 week by flushing the experimental gas-tight containers with nitrogen.

Somewhat similar results were obtained with Bartlett pears, which showed that initial anaerobiosis may lengthen storage life by about a month.

ANIMAL SCIENCE

Nicotine Sulfate for Weanling Pigs

The depth of loin fat in pigs was decreased and the carcass protein : fat ratio was increased in 2 of 3 experiments in which nicotine sulfate at 5 ppm was included in the diet from weaning time. The fat content of the livers of pigs fed nicotine sulfate at 5 ppm was 8–10% higher, at 6 months old, than that of the controls.

Feeding Diazoxamide to Pigs and Lambs

Pigs and lambs when fed diazoxamide 2 days before slaughter had cold carcass dressing percentages that were 0.76 and 2.03% higher than the controls. Diazoxamide was fed at 20 mg/kg body weight at each of three feedings. During the treating period, the weight gains of treated pigs were 2.08 kg and lambs 1.55 kg over the paired controls. Carcass water content over initial weight was increased by 6.3% in pigs and 9.7% in lambs.

Experimental Respiration Chamber

A small temperature-controlled respiration chamber suitable for carbon-14 research with pigs was developed. Wheeled digestion cages with removable fronts and floors the same height as the chamber allowed pigs to be transferred quickly to and from the respiration unit. The apparatus was used successfully in more than forty 24-hr tests in which fourteen ½- to 12-hr samples of air were obtained in each test. Pigs were placed in the chamber 2 min after receiving the radioisotope by injection and 8–10 min after receiving it in feed.

Effect of Caffeine on Feed Efficiency

Caffeine at 1.5 g/kg body weight in the feed of 65-kg pigs fed 2 kg/day for 4 weeks increased nitrogen retention by nearly 8%. Growth rate, feed efficiency, and carcass protein content were unaffected by the treatment. Weanling pigs fed the same level of caffeine until they reached market weight deposited less fat in their carcasses than the paired controls. Growth rate, feed efficiency, and carcass protein content were increased significantly. Caffeine at 1.5 g/kg of feed tended to restrict feed consumption and at 3 g/kg greatly restricted feed consumption and caused a severe skin rash. Caffeine fed at 50 mg/kg of body weight resulted in six times as much $C^{14}O_2$.

Oxidation of Glucose, Palmitate, and Valine in Pigs

The peak rate of expiration of $C^{14}O_2$ occurred earliest with C^{14}-palmitate and latest with C^{14}-glucose after injection of these compounds into pigs that had been fasted for 1, 6, 12, and 24 hr. The time of the peak was intermediate after injection with C^{14}-valine. The length of the fasting interval had no effect on the total $C^{14}O_2$ expired over the following 24 hr when C^{14}-glucose or C^{14}-valine was given, but six times as much C^{14}-palmitate was

oxidized when injection followed a 24-hr fast as compared with a 1-hr fast. Once a peak in $C^{14}O_2$ activity was reached, the decline was exponential for a period of 3–4 hr with a half-life of 1–3 hr. When C^{14}-glucose was given with the feed, the peak in $C^{14}O_2$ activity was lower and broader than when the tracer was injected. There was very little $C^{14}O_2$ expired by pigs given C^{14}-palmitate orally and no peak was detected during 24 hr after feeding. Tissue analysis 24 hr after oral administration showed that most of the unoxidized C^{14} of the palmitate tracer was in the carcass fat and very little in the muscle protein precipitated with trichloracetic acid.

Sources of Protein and Effect of Diethylstilbestrol

Lambs fed on soybean meal grew a little better than those fed on meal containing urea, but the cost of production per pound of gain was the same because of the higher cost of the feed containing soybean meal. In this experiment lambs were weaned at 8 weeks and then fed a concentrate ration containing soybean meal and good quality alfalfa hay for 18 days before the test.

Effect of Cage Housing on Semen Quality in Chickens

In this experiment 36 trios of half brothers from a White Leghorn control strain were compared after one of each trio was caged alone and the two remaining were caged together; the dominant one of the pair was determined by observation. The chickens confined singly in cages 12 × 8 × 24 inches produced the highest semen volume. The dominant one of the pair in a cage of the same size produced the next highest volume of semen. Body weight, sperm motility, fertility, and hatchability were not affected by the method of caging.

Effect on Hatchability of Storing Eggs Small End Up

The hatchability of eggs with a preincubation holding time of up to 7 days was improved by packing the eggs small end up. Hatchability of eggs stored 7–14 days was not affected, but, when storage exceeded 14 days, storage with the small end up reduced hatchability. These effects were observed in three experiments on more than 5,000 eggs.

The Hatchability of Chicken Eggs with Fractured Shells

The hatchability of chicken eggs with "basket" cracks was improved by patching with adhesive tape and by storage in nitrogen. Basket cracks located in the equatorial area were more detrimental to hatchability than similar cracks in the large end of the shell. There was no advantage in patching hairline cracks, and the location of this type of crack was not important. Storage in nitrogen of eggs with hairline cracks improved hatchability compared with storage in air.

The Effect of Different Periods of Storage in Nitrogen on Hatchability of Shipping Eggs

Eggs held in pure nitrogen for a preincubation period of up to 14 days were able to withstand rather vigorous shipping conditions without loss of hatchability. Eggs held for 21 and 28 days showed a loss of hatchability due to transportation. In this experiment eggs held in storage were compared with eggs that had been exposed to a 90-mile journey by road and a 5- to 6-hr journey by air freight, which included one transshipment en route and return to the point of origin by the same route.

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C. Veer	Soil survey
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Departures

R. J. Curtis, B.S.A., M.Sc. Resigned August 1967	Poultry and dairy cattle breeding
L. A. Dionne, B.Sc., M.Sc., Ph.D. Resigned July 1967	Potato genetics
E. A. Grant, B.Sc., M.Sc. Resigned August 1967	Forage crops
J. Munro, B.Sc., M.Sc. Transferred to Plant Protection Division, Ottawa, November 1967	Potato viruses

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[6] On educational leave at Cornell Universitly.

INTRODUCTION

This report presents the highlights of our research in 1967 and mentions new areas of research begun during the year. The results of recently started research and results that were similar to those reported previously are not included. More detailed results have been, or will be, published in various scientific journals. Good progress was made in all areas of our program. Recruiting difficulties hindered our potato breeding program.

F. Whiting
Director

AGRICULTURAL ENGINEERING AND FIELD CROPS

Potato Harvesters

Tests were started on 10 commercial potato harvesters to determine the effect of stone population, stone size, soil moisture, and type of harvester on the extent and severity of tuber bruising. Some of the harvesters were equipped with an air system to separate stones from potatoes. The ultimate aim is to determine an acceptable balance between bruising by stones and the minimum stone population needed for soil erosion control and for soil physical properties suited to potato production.

Apple Harvesters

A mechanical "shake-catch" harvesting system was used to harvest several varieties of processing and fresh fruit apples. Cracks, cuts, punctures, and bruises were more numerous on mechanically harvested fruit than on carefully hand-picked fruit. Approximately 30% of the mechanically harvested apples had bruises larger than 0.5 inch in diameter compared to 5% for carefully hand-picked fruit. Trim losses were below 1% in most instances. Work will be continued in 1968 on feasibility studies and quality evaluation of harvested fruit. The project is in cooperation with the Nova Scotia Department of Agriculture, the Nova Scotia Fruit Growers' Association, and apple growers.

Grain Combines

An evaluation was made of the design factors and operating conditions that affect grain losses in combines. The combination of small area of straw deck and overloading was found to be the chief source of grain losses. Losses from barley crops were higher than from other cereal crops. A study of grain combines available in Canada and Great Britain indicated that European combines are built with larger straw-deck areas. Combines sold in Great Britain harvest high-yielding crops under adverse weather conditions, whereas those sold in Canada are better suited to low-yielding crops under the semiarid conditions of Western Canada. The similarity of conditions in the Maritime Provinces to those in Great Britain and Western Europe points out the need to determine the relative suitability of combines being sold in Canada in relation to European combines for use in areas with heavy rainfall.

Alfalfa Fertility Studies

Naragansett alfalfa showed no response to annual surface applications of 80 lb N, 15 lb P, and 166 lb of K per acre. Yields from all plots were similar, but reached only mediocre levels, averaging approximately 2.7 tons of dry matter per acre annually over a 3-year period. The tests were conducted on a well-drained gravelly loam and on a poorly drained clay loam. Both soils were limed to a pH of 6.7 before seeding and were fertilized with P, K, Ca, and Mg, worked into the top 6 inches.

Some clues to the poor performance of these plots were provided by the analyses of the soil from various depths to 24 inches. At both locations the pH of the soil below the 6-inch level dropped to 5.1; K, Ca, and Mg were low; and soluble Al increased several times. Work will be started next year to determine if deeper placements of lime and fertilizer can overcome the apparent limiting effects of the subsoil conditions.

ANIMAL NUTRITION

The remodeling of animal and laboratory facilities begun in 1966 has been continued. Experiments were started with calves, dairy cows, sheep, and pigs. Major areas of research are the utilization of grass and corn silage, the role of rumen protozoa in the utilization of nonprotein nitrogen, the production of proteolytic enzymes by young calves, and the nutrition of pregnant sows. Projects in cooperation with Mr. T. M. MacIntyre, Experimental Farm, Nappan, N.S., were continued and reported by the Research Station, Kentville.

Calf Nutrition

Proteolytic enzymes and in vitro protein digestion (2-hr incubation of digesta) were compared in intestinal contents obtained from milk-fed lambs and calves, and from 5-month-old calves and mature sheep fed an all-hay ration. Total activities of intestinal trypsin and chymotrypsin per unit body weight increased about ten-fold as calves increased in age from one week to 5 months. Initial levels of these enzymes per unit body weight from 2-week-old lambs were three- to four-fold higher than in calves of comparable age, but increased less with advancing age.

When 0.5 or 1 g of purified soybean trypsin inhibitor (SBTI)/liter of milk was fed to a calf fitted with a reentrant intestinal cannula the result was much lower trypsin and chymotrypsin activities in the intestinal contents than when no SBTI was fed (2 to 5 units/ml vs. 10 to 40 units/ml). The highest level of SBTI caused marked diarrhea after 2 days, whereas the lower level caused little or no diarrhea. SBTI appears to cause hyposecretion rather than hypersecretion of pancreatic enzymes in calves in contrast with results reported for chicks and rats.

ENTOMOLOGY

Apple Maggots

It is commonly believed that adult apple maggots do not disperse more than 300 yd from their site of emergence. In 1966, adults marked en masse with a fluorescent powder and released at one end of a small orchard of 54 trees were recaptured in bird tanglefoot traps located in all trees in the orchard. In 1967, this technique was used to study maggot adult dispersal in a number of adjoining orchards. When laboratory-held pupae emerged they were marked and released at a point on a road west of the orchard area. It was anticipated that westerly prevailing winds would drift the flies across the experimental area. One orchard (no. 3) was located west of the release point adjacent to a continuing woods. A total of 38,614 adults were released in 20 daily releases starting on June 20. A total of 166 bird tanglefoot plywood traps, 16 × 24 inches, were hung in all orchards. By late August, 536 marked flies had been recaptured. The percentages of the recaptured flies found in each orchard and the distances from release point were as follows: Orchard no. 1, 42%, 250 yards; Orchard no. 2, 25%, 310 yards; Orchard no. 3, 15%, 375 yards; Orchard no. 4, 9%, 560 yards; Orchard no. 5, 1%, 795 yards; Orchard no. 6, 6%, 1,050 yards; Orchard no. 7, 1%, 1,350 yards; Orchard no. 8, 1%, 1,710 yards. It is evident that adult apple maggots are capable of dispersing much farther than what was commonly thought.

In tests to compare insect color attractants, sticky waxed-paper cards, 10 × 12 inches, painted red, white, blue, yellow, or green, were set about 5 ft above the ground around the perimeter of each of 51 apple trees heavily infested with apple maggots. The numbers of adults caught for each color from July 5 to August 23 were: yellow 5,378, green 5,324, white 2,056, red 645, and blue 318.

Aphid Populations on Potatoes

Aphid populations were compared on Green Mountain and Katahdin potatoes by weekly counts of whole plants. Green

Mountains supported a greater total population per plant than did Katahdins except for the last count on August 30. The sudden drop was caused in part by the greater percentage of dead foliage on Green Mountains at that time. Katahdins supported greater populations of *Myzus persicae* (Sulzer) and *Macrosiphum euphorbiae* (Thomas) throughout the season than did Green Mountains.

Aphid Control

Disulfoton and phorate are currently recommended for control of the three major aphid species, *M. persicae, M. euphorbiae* and *A. nasturtii* on potatoes. In 1967, disulfoton at 1 lb active per acre gave good control, but phorate at the same rate did not control *M. persicae* during August. At 2 lb active per acre, phorate gave control comparable to disulfoton, but the yield of grade A market potatoes was reduced. Temik[7] at 1 lb active ingredient per acre also gave good control of all three species until mid-August, but thereafter populations were greater than on the disulfoton-treated plots.

Effects of Light and Temperature on Aphids

In March 1967, from the greenhouse culture of *M. euphorbiae* maintained for several years under 18 hr of light and an average temperature of 21 C (18 H : 21 C), a new culture was established at 18 H : 10.5 C. Oviparous females appeared in the new culture about 5 weeks later. No oviparae had occurred in the greenhouse culture over the years. When third-instar nymphs from the newly established culture were mature, some of their offspring were placed in crowded and uncrowded conditions on leaves and in test tubes. Most became apterous viviparous females, but there were also several oviparous females. The production of oviparous females at 18 H : 10.5 C could have been caused by the low temperature, the decreased light intensity, and changing light quality in the greenhouse during the winter months. These factors may precondition the aphids or the plants or both so that a lower temperature, even with a long day, affected the aphids to become oviparae.

When this experiment was repeated in the summer, no oviparae were produced, which indicated that temperature alone did not bring about the previous results. Possibly aphid cultures maintained under greenhouse conditions on greenhouse-grown plants may be affected by the seasonal change in light quality and intensity, and the resultant behavior of the aphid may vary with the season.

Aphid Salivary Enzymes

The role of salivary enzymes in the aphid's selection of suitable host plants was examined by varying the type of a common host source. The aphid, *M. euphorbiae,* was cultured on entire plants, excised leaves, and rooted leaves of Katahdin and Green Mountain potatoes. Representative populations of aphids were then tested for the ability of their saliva to hydrolyze a carboxymethyl cellulose substrate by probing and secreting into it.

The percentages of times that hydrolysis resulted from such probes were as follows:

	Excised leaves	*Rooted leaves*	*Entire plants*
Green Mountain	28	33	38
Katahdin	19	34	42

The reduced activity of the enzyme when aphids fed on excised leaves indicated that the more satisfactory the host, the less demand there was on this enzyme system. It is known that aphids multiply more readily on excised leaves than on entire plants.

Wireworm Control in Potatoes

Disulfoton at 1 lb active ingredient and phorate at both 1 and 2 lb active significantly reduced wireworm damage in Katahdin potatoes. When 3 lb active phorate/acre was applied at planting, 17% of the marketable Netted Gem tubers showed wireworm damage, whereas 52% of the untreated potatoes were damaged.

Wild Species of Bees in Blueberry Fields

Fifty-nine species of native bees were collected from lowbush blueberry blossoms during a 5-year study in Maine and

[7] Available from Union Carbide Corporation.

Eastern Canada, and an additional 30 species were collected in blueberry fields but not from blueberry plants. Some species like *Bombus ternarius* Say, *B. terricola* Kirby, and *Evylaeus quebecensis* (Crawford) were common to all areas, whereas several species appeared to be limited to specific areas. Variations in the number of species in different areas may reflect differences in composition of the flora or existence of suitable soil types for nesting. *Andrena forbesii* Robertson, collected in southern Maine and in New Brunswick, was not found in Washington County, Me., a large blueberry-producing county located, geographically, between the two. *Colletes validus* Cresson was found only at Lac St-Jean, Que., and York County, Me. Soil conditions are similar in the two areas, but differences in climate indicate a broad tolerance by this species.

Blueberry Pollination

Studies carried out in the Annapolis Valley of Nova Scotia showed a satisfactory level of pollination in highbush blueberry. Both fruit set and size of berries were similar to those in commercial blueberry areas in the USA. Good pollination in Nova Scotia is achieved by native insects only, whereas in certain areas of the USA the populations of native bees are very low and honeybees are necessary to bring fruit set and yields to acceptable levels. Some evidence of varietal preference by native bees was obtained, but this preference was not reflected in fruit set in Nova Scotia.

PLANT PATHOLOGY

Common Scab of Potatoes

Common scab, *Streptomyces scabies* (Thaxt.) Waks. & Henrici, lesions were produced on potato tubers cultured in vitro. Cell-free water extracts of these lesions produced typical disease symptoms on healthy tubers growing under aseptic conditions. Extracts from scabby tubers grown in the greenhouse and in the field gave similar results. Preliminary studies have shown that the active principle is dialyzable and thermostable. We hope to isolate and characterize the scab-inducing substances.

Screening potato seedlings for resistance to the common scab disease, *S. scabies*, has usually been carried out under field conditions. This has been unsatisfactory because of uncontrollable variations in moisture and other climatic factors. To overcome some of these difficulties, a method of evaluating resistance under greenhouse conditions was developed. The potato seedlings are grown in sand and peat moss to which are added potassium nitrate, superphosphate, blood meal, and calcium carbonate. This is inoculated with cultures of the scab-producing organism or with ground peelings from scabby potatoes. The medium can be reused, after the addition of fertilizer, or mixed with new medium without further inoculation with the organism.

Late Blight of Potatoes

During 1967 approximately 5,000 potato seedlings were tested in the greenhouse for minor gene (field) resistance to late blight fungus, *Phytophthora infestans* (Mont.) de Bary, by the whole-plant and detached-leaf methods. Thirteen hundred of these seedlings selected in the greenhouse and some from other sources were also tested for blight resistance under field conditions in an isolation plot at Alma, N.B. Many seedlings showed high levels of resistance to the two races (1,3,4,6,7,8 and 1,2,3,4, 5,6,7) used as inoculum.

A race survey made in New Brunswick, Nova Scotia, and Prince Edward Island showed race 1,4 to be the predominant race. A number of races of the fungus new to this area were obtained from infections that occurred late in the summer on some seedlings grown in the isolation test plot. These included races 1,3,4,7,8; 1,2,3,4,5,7; 1,2,3,4,6,7,8; and 1,2,3,4,5,6,7,8. Preliminary tests also indicated the presence of a race that infects the R9 genotype.

An extract of the mycelium of the late blight fungus, *P. infestans*, grown in pure culture was found to inhibit infection of tobacco plants by the potato virus X. The

inhibitor was isolated in partially pure form and is known to be of large molecular size and heat stable. The solubility of the inhibitor in various solvents and the reading in the ultraviolet spectrophotometer indicated that it may be a nucleic acid with a closely bound protein group attached.

Verticillium Wilt of Potatoes

Investigations were initiated into the biology of *Verticillium albo-atrum* Reinke & Berth., the causal agent of verticillium wilt in potatoes. Early results indicated that more than one strain of the pathogen was infecting potatoes in the Maritime Provinces in 1967.

Leafroll Virus of Potatoes

More potato plants became infected with leafroll virus when viruliferous aphids, *M. persicae,* were placed on newly emerged plants than on sprouts. When comparable inoculation tests were made by infesting sprouts alone, newly emerged plants, and both sprouts and plants, 74, 100, and 98% respectively of the plants became infected. More aphids survived the inoculation access time on young plants than on sprouts (95% vs. 76%). This is a possible reason for the increased numbers of infections from plant inoculation.

After three successive generations of screening potato seedlings in a greenhouse for resistance to leafroll virus, new susceptible plants were found. From a population of 600 seedlings of different crosses and selfed lines 47, 38, and 42% became infected and were discarded in the first, second, and third generation tests. The evidence indicated that as tests continued from one generation to the next, more seedlings from a population became infected.

In earlier tests where potato seedlings were selected for resistance to leafroll virus on the basis of symptoms and random testing of lower leaves by means of aphids (*M. persicae*) and *Physalis floridana* Rydb. indicator plants, two seedlings, F4896 (Southesk × Katahdin) and F3411 (Katahdin selfed), were thought to possess high levels of resistance. Recently the use of sprouts instead of lower leaves as sources of virus for aphids was found to be a more efficient method of testing. When this method was used to test tubers from these seedlings, a severe strain of the virus was transmitted to the indicator plants, which demonstrated that the seedlings were not resistant, but were symptomless carriers of the virus.

Potato Spindle Tuber Virus

Highly infectious nucleic acid was obtained from potato and tomato plants infected with potato spindle tuber virus (PSTV) by treating the buffered tissue extract (TE) with water-saturated phenol, washing with cold ether, and precipitating with 95% ethanol. Experiments on dilution, thermal stability, ribonuclease sensitivity, and sedimentation all indicated that in TE the nucleic acid (NA) was influenced by some other factor. Some of the influence may come from a virus protein. However, the relative infectivity and the thermal stability material in sap of healthy plants, probably protein, could account for the most obvious differences between TE and NA. The protein and whole virus particle of PSTV seem to be elusive. It has been suggested that they might not exist and that the PSTV is free RNA. The results here tend to support this reasoning.

A protein antigen, demonstrated in tomato plants, infected with PSTV, and apparently absent from healthy plants was first thought to be the protein coat of the virus. Later the antigen was detected in older healthy tomato plants. It increased rapidly in newly infected young plants, but developed more slowly, and not to the same extent, in healthy plants. Serological diagnosis of the virus seems possible in tomatoes, but not in potatoes by the present techniques because their concentration of the protein is lower.

Aphids as Vectors of Viruses

An excellent source of stylet-borne virus was found in the secondary veins of tobacco leaves infected with a strain of cucumber mosaic virus. After one brief probe into such a vein 88% of the aphids (*M. persicae*) transmitted the virus. This is the highest level of transmission that has been reported for a stylet-borne virus by aphids.

Auxin Production in Lowbush Blueberries

In continuing investigations on parthenocarpic fruit set and auxin levels in flower buds and fruits of the lowbush blueberry, *Vaccinium angustifolium* Ait., evidence was obtained that the presence of auxin in flower buds depends on the photoperiod under which the plants are grown. Under short-day conditions (8 hr), flower buds formed in 8 to 9 weeks, whereas under long-day conditions (14 hr), relatively few flower buds formed and these required at least 17 weeks. New vegetative growth was produced under long-day but not under short-day conditions. Auxin was present in flower buds formed under short-day but absent from those formed under long-day conditions. Flowers from buds formed under short days develop into parthenocarpic fruit of normal size when treated with gibberellic acid at concentrations of 20 to 50 ppm. Gibberellic acid (GA) applied at the same concentrations to flowers formed under long days produced parthenocarpic fruit, which usually stopped growing about 4 weeks after anthesis. Therefore, the parthenocarpic response to applications of GA seems to be mediated by the presence or absence of auxin in flower buds.

Development of Strawberry Fruits in Vitro

Pollinated and unpollinated flowers and fruit tissues of the cultivated strawberry, *Fragaria ananassa* Duch. var. Sparkle, were grown on synthetic media in sterile cultures and studies made on the effects of gibberellic acid (GA), indolebutyric acid (IBA), naphthalene acetic acid (NAA), kinetin, the calyx, and light on fruit formation. In the pollinated flowers, as in nature, the shape, size, and growth of the fruits depended on the number of fertilized ovules. The fleshy receptacle turned pink in 4 weeks and the fruits ripened in about 7 weeks. The achenes showed normal embryos. High light intensities enhanced ripening and the fruits were dark red, whereas under diffuse light the fruit remained pink. The fruits tended to be undersized when the calyx was removed at inoculation. In a medium containing IBA plus kinetin, disclike patches of callus or roots or both appeared on the pedicel. Low concentrations of IBA or NAA (5, 10, or 20 ppm) slightly increased fruit size, but higher concentrations (50 or 100 ppm) were inhibitory. With the addition of GA (5 and 10 ppm) the fruits ripened 1 week earlier.

In 1-day-old emasculated and unpollinated flowers the basal portion of the receptacle was induced to grow with GA, but development of the fruit was not complete. The incorporation of IBA or NAA into the medium did not reduce parthenocarpic development. The growth of the fruit-tissue cultures depended on the age of the inoculum. Young and immature tissues proliferated readily, but nearly mature tissues required more time to grow. Under high light intensities the cultures had a tendency to develop anthocyanin and chlorophyll.

Respiration and Photosynthesis in Potatoes

In studies to measure the mode of action of various potato top killers (herbicides) on the yield of marketable potatoes a method using $C^{14}O_2$ to measure respiration and photosynthesis was developed. Other workers had exposed the potato plant to about 4 μc of $C^{14}O_2$ for 1 to 2 hr and waited up to 8 days for material to translocate from the leaves to the tubers. We found that the tubers can be made to accumulate high specific activity (3,300 cpm) in 24 hr.

The apparatus housing the plant has a chamber for controlling humidity at 35% RH by means of a saturated solution of $CaCl_2$ and two traps, one to release $C^{14}O_2$ from Na_2CO_3 upon addition of acid, and the other to absorb any free $C^{14}O_2$ at the end of the experiment in $Ba(OH)_2$. Light was supplied at 2,000 ft-c for 16 hr/day to drive photosynthesis at a high rate. Experiments were begun at the beginning of the photoperiod. After 24 hr the atmosphere in the apparatus was passed through the alkali and sections of plant tissue were measured. We obtained 12 to 30 times as much labeled material in the tubers by this method as had been obtained by other methods.

Potato Vine Desiccation

Eighteen treatments were applied at a pressure of 30 lb psi in 40 gal of water/acre to potatoes on two dates to study the effect of maturity of a moderately early variety (Keswick, on August 18 and August 25), and a later variety (Netted Gem, on August 25 and September 1) on vine desiccation. Within 2 weeks after treatment the leaves and stems were completely desiccated on both varieties and for both dates of application by the following treatments per acre: sodium arsenite at 10 lb; sodium arsenite at 5 lb plus urea nitrogen at 10 lb; diquat at 6 or 8 oz plus Agral 90 surfactant; paraquat at 6 or 8 oz; diquat at 4 oz plus paraquat at 4 oz plus Agral 90; linuron at 2 lb plus duPont KW surfactant; endothall (Des-i-cate) at 1.25 lb; and endothall at 1.25 lb plus 3 gal of diesel oil as an additive. Sodium arsenite at 5 lb and ametryne at 3 lb desiccated Keswick vines after both dates of application and Netted Gem after the last date. The 5-lb rate of sodium arsenite was not sufficient to completely desiccate the immature vines of Netted Gem.

POTATO BREEDING

Evaluation for French Fry Quality

Promising seedlings within the potato breeding program were evaluated for French fry quality by scoring each sample for external appearance, external color, internal color, texture of slices originating near the surface of the tuber, and texture of slices originating from the pith area of the tubers. The evaluation of several thousand samples has led to the conclusion that the major weakness of most seedlings is poor texture of the slices originating from the internal parts of the tuber. Data from 44 seedlings gave the following simple correlations:

Specific gravity of whole tuber – dry matter of outside slices .....+0.75
Specific gravity of whole tuber – texture of outside slices .....+0.66
Specific gravity of whole tuber – dry matter of inside slices .....+0.52
Specific gravity of whole tuber – texture of inside slices .....+0.39
Dry matter of inside slices – texture of inside slices .....+0.63

These values indicate that the dry matter of inside slices as determined by oven-drying is a better indicator of the texture of inside slices than the specific gravity of the whole tuber and may have value as a preliminary screen for French fry quality in breeding populations.

The new variety Grand Falls released in 1965 is superior in French fry quality to other varieties presently grown in Canada when rated on external appearance, external color, internal color, texture of outside strips, and texture of inside strips. Its one shortcoming compared with the standard French fry variety Netted Gem is that its tuber is a round rather than a long variety and consequently the French fry strips are shorter.

Cariboo

The potato variety Cariboo (F5561) was released jointly by the Research Station, Agassiz, B.C., the Experimental Farm, Prince George, B.C., and the Research Station, Fredericton, N.B. It has an excellent yield record in trials conducted at several locations in British Columbia. In all trials it was equal or superior in yield to Netted Gem and Kennebec. Cariboo is of late maturity and has a distinctive appearance with pink eyes and some pink skin at the seed end of the tuber. It is top necrotic to viruses X and B, highly resistant to verticillium wilt and Phoma tuber rot, and slightly resistant to common scab. Cariboo is recommended as a main crop variety for the interior of British Columbia.

Seedling Selection

In order to gain further information on the best stage for distributing potato seedlings to cooperating stations from a central breeding unit, the work begun in 1962 and 1963 with unselected first clonal generation seedlings was continued into the second clonal generation in 1963 and 1964 at Preston, Ont., and Alma, N.B.

Seedlings selected the previous year were again subjected to a screening process at both locations by two cooperators working independently. From a total

of 427 second-generation seedling clones replanted in 10-hill plots at Preston over the 2-year period, 81 reselections were made. Of this number, 41% were reselected by both cooperators. At Alma, 300 seedling clones were replanted in the same period and 82 reselections were made. Of these, 29% were reselected by both cooperators.

Each cooperator reselected approximately 75% of the seedlings that he originally selected in the first clonal generation and about 25% of the other cooperators' selections, regardless of location. For the 2-year period four seedlings were reselected by one cooperator at both locations and 11 by the other; only one seedling was reselected by both cooperators at both locations.

It was concluded that distribution of potato seedling material from a central breeding unit to stations that have the facilities to handle large populations at the second clonal generation has marked advantages over distribution at the third or later generation.

SOILS

Denitrification in Podzols

Investigations of what happens to fertilizer N in soils indicated that denitrification is a potential source of N loss. Preliminary studies using gas chromatography confirmed the evolution of N gas and N_2O after short periods of incubation.

The extent of denitrification, the factors affecting it, and the sequence of the formation of volatile products have been complicated by difficulties in maintaining aerobic conditions or any specified oxygen level during incubation. This has been resolved by the production of oxygen from barium peroxide – barium hydroxide in a flask attached to the incubation flask by a side arm. The addition of this system will enable a study of N transformations in soils maintained at any desired O concentration for extended periods.

Response of Potatoes to Magnesium

Mg fertilizer increased potato yields at 5 of 26 field sites evaluated during 1965, 1966, and 1967. A response was obtained when the exchangeable Mg level of the soil was less than 0.3 meq/100 g. Under these conditions, the Mg content of the petioles at the bloom stage was less than 0.3%. Applied Mg (30 lb/acre from $MgSO_4$) increased the Mg content of the foliage at all locations, but had no effect on specific gravity or quality of tubers. Preliminary results indicated that fine dolomite, brucite, potassium magnesium sulfate, and magnesium silicate, applied in the fertilizer band, are effective sources of Mg for potatoes.

Source of Potassium on Potato Yield and Quality

The effects of chloride, sulfate, and nitrate sources of K on yields, specific gravity, French fry quality, and chemical composition of Netted Gem potatoes were compared at six locations in Carleton County during 1965, 1966, and 1967. The K fertilizers were applied at 0, 50, 100, 150, and 200 lb K/acre, with three replications at each location.

Total yields were not affected by the K source, although yields increased with the first 50-lb increment of all sources. Each additional increment of K significantly decreased specific gravity. It was lowest with the chloride and highest with the sulfate source.

French fry quality was significantly better with the nitrate source. The chloride or sulfate sources were not significantly different, although chloride resulted in a lighter color French fry. Increasing rates of K from all sources resulted in poorer texture of inside slices, but did not affect other quality characteristics.

N, P, Mg, and Ca concentrations in petioles decreased with increasing rates of K, whereas K and chloride levels increased with all sources except the KNO_3 source, which reduced chloride concentrations.

Effect of Stones on Potato Yield

Previous work on Undine soil was extended to three other major potato-growing soils, namely Holmesville, Monquart,

and Caribou. Results for 1 year indicated that potato yields declined when stones were removed from the Holmesville soil.

Tolerance of Crops to Salt

To determine the relative salt tolerance of crops grown on coastal alluvial soils, soil salinity levels were created by adding NaCl to a normal upland soil. The resulting electrical conductivity of saturated extracts (E.C.e) ranged from 2.5 to 20 mmhos/cm. Crop germination varied with oats>barley>timothy>clover. Yields equivalent to 70 to 80% of those obtained on comparable, nonsaline soils indicated that oats was the most tolerant crop, followed by barley, clover, and timothy. Approximate E.C.e values at these yield levels were 5-4, 4-3, 4-3, and 3-2 respectively. E.C.e values as an indication of salt tolerance of these crops were lower than those reported for saline soils in arid zones. Although barley is reported to be more salt tolerant than oats, release of Al by the addition of NaCl in our soils is the probable cause of this anomaly. This was suspected from visual symptoms on barley and was confirmed in a laboratory study.

Soil Survey

During 1967 the land capability of the Woodstock (21J) and Moncton (21I) map sheets and the soil survey report for northern Victoria County were completed. The latter has a section on soil suitability for engineering, various recreational purposes, urban development purposes, various agricultural crops, and tree species.

Preliminary tests conducted in the Bettsburg area indicated that Reece sandy loam is suitable for potato production. Extensive areas of this soil with good topography and limited stoniness are available in New Brunswick.

WEED CONTROL

Detailed results of research with various herbicides are available in the Annual Research Report of the National Weed Committee, Eastern Section, published by the Canada Department of Agriculture, Ottawa. The results that follow refer primarily to commercially available herbicides. Rates of herbicides listed are active ingredient or acid equivalent per acre. No tests were conducted for residues in the crops.

Weeds in Strawberries

Simazine at all rates gave better weed control in the fruiting year than did cultivation alone. No advantage was gained from rates in excess of 1 lb active ingredient/acre. Cultivation following simazine application did not diminish the long-term effectiveness of the herbicide. Significantly better weed control resulted from cultivation and herbicide treatment. Improved control with cultivation was attributed to the removal of pockets of perennial or other weeds resistant to the herbicide. Noncultivated plots produced less fruit in 1966, but were comparable with cultivated plots in 1967. Runner plants rooted more slowly and plant stands were somewhat less in noncultivated plots. The delay in rooting was attributed to the surface crust on noncultivated plots, but this was not considered to have significantly influenced yields.

The results indicated that a system of noncultivation may have possibilities as a commercial practice in New Brunswick when combined with a program of preplanting land preparation for the removal of perennial weeds and herbicide application(s) after planting.

Lambkill in Lowbush Blueberries

Dicamba at 2 to 3 lb applied in early October, followed by burning early the next spring, continued to be superior to 2,4-D ester for the control of lambkill, *Kalmia angustifolia* L., among lowbush blueberries. Early fall application of dicamba slightly thinned the blueberry stand, whereas late applications severely reduced the stand.

Weeds in Peas

In 3 previous years linuron treatment immediately after planting gave excellent

control of weeds and the highest yields of peas. In 1967, application was delayed until 8 days after planting. Linuron at 2 lb killed all the peas, and at 1 lb reduced the stand 30% and the yield 60%. Peas on the linuron-treated plots emerged and grew 2 to 4 inches before they died. Heavy rainfall was not a factor.

Annual Weeds in Potatoes

Twenty-five herbicide treatments were tested on Netted Gem potatoes for control of annual weeds. Excellent control was provided by metobromuron (Ciba 3126) at 3 lb, ametryne at 1.5 and 3 lb applied near emergence of potatoes, and Terbacil[8] applied at 1 lb soon after planting. Good control was obtained with dinoseb at 3.6 lb at emergence, monolinuron at 2 lb after planting, dinoseb at 1.8 lb plus monolinuron at 1 lb after planting, linuron at 2 lb after planting, metobromuron at 2 lb early postemergence (potato tops 4 inches), diquat at 1 lb early postemergence, prometryne 2 lb at emergence, chloroxuron 5 lb at emergence either on the surface or incorporated in the soil, and chloroxuron 5 lb at early postemergence. None of these treatments affected potato yield. All untreated weedy plots had lower yields.

[8] Available from Du Pont of Canada Ltd.
[9] Available from Stauffer Chemical Co.

Quackgrass in Potatoes

Eighteen herbicide treatments were applied to Netted Gem potatoes infested with quackgrass (couch). Eighty percent control of quackgrass was obtained with dalapon at 8 lb either at potato emergence or at early postemergence (tops 3 inches high) followed in either case by cultivation 10 days later, or with dalapon at 5 lb at emergence followed 3 days later by either EPTC[9] or chloroxuron at 5 lb incorporated into the soil. Terbacil at 1 lb after planting reduced quackgrass infestation to a level comparable to the hand-hoed plots. Terbacil at 4 lb after planting killed 90% of the potatoes.

Hellebore in Hay Fields

White hellebore, or Indian poke, *Veratrum viride* Ait., a weed poisonous to livestock, is resistant to many herbicides. Diquat applied at 1 lb before June 7 gave 80% control of hellebore. The addition of 6 lb of N as urea increased the control by 10%. Retreatment of escaped plants the following spring is necessary for control.

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Tabac

J. Allard, B.S.A.	Culture du tabac jaune
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P. P. Lukosevicius, Diplomlandwirt, M.Sc., Ph.D.	Génétique et amélioration du tabac à cigare

Grande Culture et Horticulture

J. Genest, B.S.A.	Céréales, plantes fourragères et horticoles[2]

INTRODUCTION

Ce rapport n'est qu'un court résumé des travaux de recherches accomplis à la Ferme expérimentale de L'Assomption en 1967. À la date où ce rapport fut présenté nous ne possédions qu'une partie des résultats. Ceci est particulièrement vrai pour les expériences sur les tabacs à cigare dont les données de récolte ne sont connues que durant l'hiver. On trouvera d'autres résultats de ces expériences dans les articles déjà publiés ainsi que dans les prochains rapports.

J. Richard
Le directeur

OBSERVATIONS MÉTÉOROLOGIQUES

En 1967, la saison de végétation a débuté très lentement. En mai, la température moyenne fut 6.7 degrés F inférieure à la normale. Juin et juillet furent plus chauds. Août, septembre et octobre furent semblables à la moyenne. La précipitation fut inférieure à la normale durant la saison de végétation, excepté en octobre. En septembre, la durée d'insolation fut supérieure à la moyenne. La saison de végétation fut plus longue de quelques jours.

[1] S'est joint au personnel le 9 août 1967.
[2] Les travaux sur les petits fruits sont sous la direction de M. R. Granger, agent de recnerche, St-Jean, Qué.

HORTICULTURE

Fraises

Essai de variétés de fraisiers indexés—Les fraisiers plantés en 1966 rapportèrent en 1967. Les moyennes de rendements à l'acre en livres furent:

Guards-man	Red-coat	Cava-lier	Mid-way	Poca-hontas	Earli-dawn
11,118	8,502	7,848	7,194	6,540	5,886

Les valeurs soulignées par la même ligne ne sont pas significativement différentes à 5 p. cent selon le test Duncan.

Essai avec le Alar-85 sur fraisiers indexés—Les variétés de fraisiers indexés, Redcoat, Sparkle, Cavalier et Guardsman, plantés en mai 1966 furent traités à 1,000 et 2,000 p.p.m. de «Alar-85»,[3] le 21 juin, le 13 juillet et le 17 août 1966 et 1967.

Les traitements au Alar-85 n'ont pas réduit significativement la production des stolons et ils ne retardèrent pas la période de cueillette des variétés Cavalier et Redcoat. Les applications de 1,000 et 2,000 p.p.m. le 21 juin retardèrent la période de 2 et 4 jours dans le cas de la Sparkle, et de 3 et 6 jours dans le cas de la Guardsman. Les applications de la mi-juillet retardèrent la période de cueillette de la Sparkle et de la Guardsman de seulement 1 et 3 jours. Les rendements n'ont pas été significativement augmentés par les applications du Alar-85.

Framboises

Essai de variétés de framboisiers indexés—Les framboisiers indexés plantés en octobre 1962 donnèrent leur quatrième récolte en 1967. Malgré que la plupart de ces framboisiers furent atteints de maladies virales depuis l'été 1966 leurs moyennes de rendements en livres à l'acre en 1967 furent:

Madawaska	Trent	Latham	Muskoka
10,459	9,519	8,363	7,857

Muskoka	Carnival	Comet	Tweed
7,857	7,109	7,037	6,435

Les valeurs écrites sur la même ligne ne sont pas significativement différentes à 5 p. cent selon le test Duncan.

Essai avec le Alar-85 sur framboisiers indexés—Des framboisiers indexés des variétés Trent et Latham plantés en 1965 furent traités en 1967 pour la deuxième année consécutive avec 1,000 et 2,000 p.p.m. de Alar-85, le 21 juin, le 14 juillet et le 18 août.

Les applications de juin à 2,000 p.p.m. ont retardé considérablement la croissance des plants alors que celles de juillet n'ont presque pas affecté la croissance des plants. Les applications d'août 1966 ont retardé la croissance des tiges en 1967 ainsi que la période de cueillette des fruits. Le Alar-85 aux deux concentrations réduisit très significativement le gel des tiges surtout lorsqu'appliqué en juin et juillet. Les tiges traitées en 1966 donnèrent en général un peu plus de fruits en 1967 que celles non traitées.

GRANDE CULTURE

Plantes fourragères

Établissement—Cette étude a débuté en 1966 afin de solutionner le problème des aléas de l'établissement des prairies et pâturages dans le Québec.

Le présent travail porte sur l'établissement du brome, du mil, de la luzerne et du lotier. Ces espèces ont été ensemencées à deux taux différents, l'un étant le taux actuellement recommandé par le Comité des Prairies et Pâturages du Conseil des Semences du Québec et l'autre la moitié du précédent. Les semis ont été effectués en compagnie d'avoine, de blé et d'orge ainsi que sans céréale-abri. Les céréales ont été récoltées à maturité sur une partie

[3] UniRoyal Limited.

de l'expérience et ont été fauchées régulièrement dans l'autre partie. Le rôle d'une application d'herbicide a également été évalué.

Le succès de l'établissement des espèces fourragères dépend entièrement de la compétition fournie pas les céréales-abri et les mauvaises herbes.

L'utilisation de taux réduits n'a pas affecté l'établissement, sauf chez le lotier où l'on a enregistré des rendements légèrement inférieurs l'année suivant l'ensemencement.

Les meilleurs établissements ont été obtenus en l'absence de céréale-abri; suivent dans l'ordre: le blé, l'avoine et l'orge.

Contrairement à la pratique admise, la fauche régulière de la végétation ne favorise pas invariablement l'implantation de l'espèce fourragère. La fauche de la céréale augmente sa durée de vie et prolonge la période où l'espèce fourragère et la céréale-abri luttent pour l'eau et les éléments nutritifs du sol.

Ce fait est plus évident lorsque l'espèce fourragère et la céréale-abri ont un système radiculaire similaire et que la compétition s'accentue à ce niveau. Cependant cet énoncé ne s'applique pas au blé (Selkirk) qui n'eut pratiquement aucun regain après la fauche.

L'application d'herbicide contribue à diminuer la compétition due aux mauvaises herbes et elle est bénéfique dans tous les cas où elle n'endommage pas l'espèce fourragère.

Dans la plupart des cas, l'utilisation de meilleures méthodes d'ensemencement et de régie a permis de doubler la première récolte de foin.

Maïs-grain

Essais d'hybrides—Les essais présentement en cours se limitent à éprouver les hybrides susceptibles de convenir à la culture du maïs-grain dans la région. La liste des hybrides, alliant un rendement satisfaisant à une maturité assez hâtive pour convenir à cette fin, s'allonge continuellement. Aux hybrides Haapala H-175 et Morden 88, mentionnés dans notre dernier rapport, s'ajoutent Warwick SL-209, M.C. 101 et Pride 116.

Plantes oléagineuses

Essai de variétés de Colza—Seul l'essai de Colza nous a fourni des faits nouveaux en 1967. Les rendements de 2,100 kg/ha de *Brassica napus* sont très satisfaisants, par contre les 1,200 kg/ha de *B. campestris* le sont beaucoup moins. Chez *B. napus* la lignée exempte d'acide érucique SZ 62-11 a produit plus de 2,400 kg/ha. Les variétés Tanka et Target ont produit respectivement 2,300 et 2,100 kg/ha. La plus productrice des variétés de *B. campestris* a été Echo avec un rendement de 1,400 kg/ha. Les pourcentages d'huile de la graine sont tous satisfaisants.

Cependant, les variétés de Colza présentement à l'essai sont toutes susceptibles à la verse et à l'égrenage. Ces deux facteurs contribueront certainement à limiter l'expansion de cette culture au cours des prochaines années.

TABAC

Tabac à cigare

Hybridation—Comme dans les années antérieures, des travaux d'hybridation furent effectués en 1967 entre les variétés de tabac à cigare et à pipe d'origine variée afin d'élargir les possibilités de sélection en introduisant du nouveau plasma germinatif. Trente-cinq nouveaux croisements ont été réalisés visant surtout l'amélioration de l'arôme et du goût. La première génération filiale (F_1) fut produite en serre durant les mois d'hiver.

Études sur l'hérédité—Comme en 1966, l'influence du géniteur femelle dans le cas du tabac à cigare a été étudiée. L'effeuillage et le classement ne sont pas encore terminés. Cependant, d'après les mesures prises au cours de la période de végétation, il semblerait que les conclusions relatives à l'importance du choix du géniteur femelle,

en général, furent confirmées. Les conditions du milieu dans certains cas ont masqué la grandeur des différences entre les hybrides de divers croisements réciproques. Ceci fut particulièrement vrai pour la hauteur des plants avant et après l'écimage.

Études sur le séchage—Chose étrange, on a trouvé moins de dommage par le chauffage à la pente sur le tabac séché dans les conditions ordinaires, où le tabac a perdu 72.6 p. cent de son poids initial pendant une période de 24 jours. Le plus de dommage a été constaté sur le tabac séché à l'aide de la ventilation supplémentaire pour la même période de temps et la diminution de poids fut de 69.0 p. cent. Le tabac séché à l'aide de ventilation et de chauffage supplémentaires a perdu 71.6 p. cent de son poids initial et fut quelque peu endommagé par le chauffage à la pente, en comparaison du tabac séché à l'air naturel.

Études de fertilisation—La moyenne des résultats obtenus sur trois fermes en 1966, indiquent que l'engrais chimique à tabac à cigare, qui contenait 6 p. cent de soufre, a produit un tabac dont l'indice de qualité et de revenu étaient plus élevés que celui obtenu par l'usage de l'engrais à 12 p. cent de soufre. Un rendement légèrement plus élevé a été obtenu par l'emploi de l'engrais chimique à 12 p. cent de soufre.

Méthodes de culture—Dans une étude sur les effets du stage et de la hauteur de l'écimage et de l'espacement des plants sur le rendement et la qualité du tabac à cigare, le rendement, l'indice de qualité et de revenu furent plus élevés lorsque le tabac fut écimé dans la phase du bouton. L'écimage normal à 14 feuilles a donné l'indice de qualité et de revenu le plus élevé. L'espacement des plants à 16 pouces sur le rang a augmenté le rendement mais a eu tendance à abaisser l'indice de qualité.

Sélection, évaluation préliminaires et finales—Dans les parcelles de sélection, un total de 375 lignées furent cultivées. En s'appuyant sur les observations au champ, un peu plus qu'un sixième des lignées furent rejetées, ce qui laissait 308 lignées pour une élimination ultérieure après le séchage. En général, les lignées qui provenaient de croisements comprenant des variétés de tabac à pipe aromatique avaient moins de feuilles par plant que celles issues de variétés à haut rendement et des variétés commerciales.

Comme en 1966, 30 des lignées les plus prometteuses furent évaluées en essais préliminaires. Cette évaluation préliminaire fut conduite en duplicata et en comparaison des variétés commerciales cultivées, Ottawa 705 et Resistant Havana 211. Le classement n'est pas terminé à date. Cependant, d'après les observations faites au champ, les lignées S13-22X et HL64-17-01-01F_4 avaient un plus grand nombre de feuilles par plant que les variétés commerciales cultivées. La lignée HL64-17-01-01F_4 est passablement tardive et il faudrait la sélectionner davantage pour améliorer sa hâtivité.

Le nombre de variétés et de lignées dans l'essai final était le même qu'en 1966. Les 10 lignées et variétés évaluées en 1967 ont fleuri plus tôt qu'en 1966. La lignée SL64-I.C.B.-02 a fleuri 7 jours plus tôt. Des conditions de température favorables durant la première moitié de la période de végétation a hâté le développement des plants, cependant, le manque d'humidité durant la seconde partie a réduit le développement des plants. Toutes les lignées évaluées avaient moins de feuilles par plant en comparaison de la récolte de 1966. Les résultats du séchage ne sont pas disponibles, vu que le classement n'est pas encore terminé.

Résistance aux maladies—Un total de 228 lignées furent cultivées dans le champ d'observation. La majorité d'entre elles étaient des lignées engendrées pour évaluer leur résistance à la pourriture noire de la racine causée par le champignon *Thielaviopsis basicola* (Berk & Br.) Ferr. Une prédisposition considérable au champignon de la pourriture de la racine fut observée dans six lignées. Les variétés commerciales Resistant Havana 211 et Ottawa 705 étaient aussi légèrement atteintes.

Tabac jaune

Évaluation des variétés—Dans cet essai nous avons étudié la valeur agronomique des nouvelles lignées ou variétés en les comparant aux variétés standard Hicks Broadleaf, Yellow Gold, White Gold et Delcrest 66.

Les nouvelles lignées ou variétés Virginia 115, 205, P-46-A, A-34, P-57-4, D-14, Bell 15 et Reams 61 ont présenté un revenu brut comparable à celui de la variété standard Hicks Broadleaf. Toutefois, les lignées A-34 et 205 caractérisées par un rendement très élevé ont poussé une feuille de qualité moindre. Les variétés Delcrest et McNair 30 se sont révélées inférieures aux variétés Delcrest 66 et Hicks Broadleaf au point de vue rendement et qualité de leur tabac.

Il n'y a pas de différence marquée entre les variétés pour l'indice de maturité, cependant la variété White Gold a semblé plus hâtive à mûrir sa feuille alors que Yellow Gold a été beaucoup plus lente.

L'analyse des mesures de croissance indique que Virginia 115 a fourni le plus de feuilles par plant (16.5) suivie de près par la variété Delcrest 66. White Gold a donné les plus petites feuilles.

Méthodes culturales—Nous avons poursuivi l'étude du comportement de trois variétés de tabac jaune soumises à trois taux de compacité et trois taux de fertilisation.

La variété Delcrest 66 s'est avérée plus rentable que Hicks quant à son rendement, à la qualité de sa feuille et à son revenu brut, mais inférieure pour son indice de maturité.

L'espacement des plants sur le rang à 22 pouces a donné un rendement supérieur aux plants distants de 24 et 26 pouces.

Des divers traitements d'engrais comparés, soit 1,000, 1,250 et 1,500 livres à l'acre de 2-12-12 T, nous avons observé qu'à une plus grande quantité d'engrais correspondaient un rendement supérieur et un indice de revenu brut amélioré même si la qualité de la feuille était diminuée. La forte dose d'engrais a sensiblement retardé la maturation de la feuille.

Irrigation—Cet essai a pour but d'adapter la méthode du budget d'eau à la détermination du besoin d'irrigation pour le tabac jaune. Une précipitation modérée et bien répartie durant la saison de végétation a limité le besoin d'irrigation à un arrosage. Cet arrosage fut très profitable à la croissance du tabac. Nous avons constaté que le tabac irrigué suivant la méthode du budget d'eau a donné d'aussi bons résultats que celui irrigué suivant la méthode des unités hygrométriques.

L'apport de diverses doses d'engrais 2-12-12 T, soit 1,200 et 1,500 livres à l'acre, a assuré un revenu brut identique. La majoration du taux d'engrais a provoqué une hausse de rendement mais elle a légèrement déprécié la qualité de la feuille et retardé sa maturité.

AVICULTURE[4]

Volailles à chair

Études de sélection—On a continué de réaliser des progrès génétiques dans les lignées sélectionnées pour leur rythme de croissance. Le poids vif de la lignée la plus poussée, à 56 jours, dépasse d'environ 35 p. cent la population de base dont elle provient (après huit générations de sélection). Les croisements de lignées sélectionnées pour la croissance, visant à accroître le potentiel génétique des futures sélections, se sont traduits par une meilleure aptitude à la reproduction chez la lignée résultante. Il est encore trop tôt cependant pour affirmer si cette méthode peut produire des progrès plus marqués dans la sélection.

Le taux de mortalité des sujets adultes en 1967–1968 a été excessif. Le phénomène ne semble pas devoir être attribué à une cause dominante en particulier et on ne peut pas non plus le rattacher à une ou l'autre des lignées de sélection (le taux a varié de 36 à 45 p. cent chez les lignées à l'essai).

[4]Les travaux de génétique avicole sont sous la direction du Dr. E. S. Merritt et ceux de nutrition sous la direction du Dr. J. R. Aitken, Ottawa, Ont.

Études de nutrition—Des poussins de volailles à chair ont reçu diverses rations de début (12, 15 et 22 p. cent de protéine) et de croissance (12 et 16 p. cent de protéine). Le but de l'expérience était d'étudier les conséquences d'un régime à faible teneur en protéine au début de la croissance sur les aptitudes reproductrices ultérieures. Les rations faibles en protéine ont retardé sensiblement la croissance, mais n'ont eu aucun effet sur la mortalité durant la période de croissance.

Dans les poulaillers de ponte, la production d'œufs résultant d'une ration de début à 12 p. cent de protéine a été trop basse, mais un taux protéique de 15 p. cent a donné une ponte égale ou même supérieure au taux de 22 p. cent. Pour ce qui est de la ration de croissance, le taux protéique de 12 p. cent s'est traduit par une ponte meilleure que celui de 16 p. cent, même lorsque la ration de début de ces poulettes avait été très pauvre en protéine. Les résultats laissent à penser que les volailles à chair ont besoin de beaucoup moins de protéine dans la phase de croissance que l'on ne le suppose couramment et qu'un faible niveau protéique dans la ration durant cette période peut être préférable.

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Station de Recherches

Lennoxville, Québec

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[1] Nommé, septembre 1967.
[2] Démissionné, octobre 1967.
[3] Nommé, mai 1967.

INTRODUCTION

Le présent rapport consigne les résultats de certains travaux de recherches obtenus durant l'année 1967. Il résume les données de projets en cours depuis plusieurs années ou terminés récemment.

Le progrès de la Station, au cours de l'année a été remarquable. En premier lieu, deux jeunes spécialistes se sont joints au personnel scientifique, l'un en physiologie animale et l'autre en physique des sols. Ces deux nouvelles disciplines sont essentielles à notre programme de recherches. Par contre, W. Holtmann, spécialiste en génétique animale, a démissionné pour accepter un poste de professeur à la Faculté d'Agriculture de l'Université Laval. En second lieu, il faut souligner la construction d'un pavillon de service (60 × 160 pieds) pour les divisions de phytotechnie et des sols pour remplacer le vieux pavillon des sols cédé à l'Université Bishop. En octobre 1967, on a mis en chantier une grange-étable (72 × 247 pieds) destinée à loger quelque 120 vaches en lactation et une soixantaine de veaux. Cette construction représente la dernière étape dans la réalisation d'un centre de recherches laitières commencée il y a 10 ans. Enfin, mentionnons le renouvellement du système électrique—primaire et secondaire. Cette amélioration était devenue nécessaire à cause du danger de feu permanent que présentait l'ancien système et de la demande toujours croissante d'énergie pour alimenter les laboratoires, les serres, les séchoirs, et tous les moteurs.

Toutes ces additions et améliorations ont été effectuées en vue de faciliter la recherche et d'augmenter l'efficacité de la Station.

Plusieurs nouveaux projets ont été initiés au cours de l'année. Mentionnons entre autres le contrôle de l'anoestrus chez la brebis par le croisement et la sélection; la mise en production des terres nouvellement défrichées; et la valeur alimentaire comparative de différentes graminées comme pâturage pour agneaux, ce dernier en coopération avec la Ferme Expérimentale de Normandin.

P. E. Sylvestre
Le directeur

ZOOTECHNIE

Valeur nutritive des maïs fourragers ensilés à différentes dates

Deux variétés de maïs fourrager, l'une hâtive (Pride 5), l'autre tardive (Warwick 600), furent ensilées les 6 et 26 septembre chacune, soit avant et après les premières geléees d'automne. Ces quatre différents ensilages furent servis à de jeunes bouvillons. La consommation moyenne en matière sèche pour la variété hâtive a été de 8.4 livres par tête et par jour, indépendamment de la date de mise en silo. Cependant le maïs ensilé le 6 septembre a produit des gains journaliers de 0.75 livre comparé à 0.90 livre pour l'autre. Avec la variété tardive, la consommation de matière sèche par jour fut de 6.5 livres pour l'ensilage du 6 septembre comparée à 7.9 livres pour celui du 26 septembre. Les gains journaliers furent de 0.85 et 0.58 livre pour les deux ensilages.

Par livre d'augmentation de poids, les bouvillons consommèrent 10.2 livres de matière sèche en ensilage de maïs hâtif (Pride 5) comparé à 11.8 livres pour la variété tardive. Calculée d'après les rendements en ensilage, les quantités consommées et les gains journaliers, l'augmentation de poids des bêtes à l'acre a été de 856 livres et 1,255 livres pour la variété hâtive coupée le 6 et le 26 septembre, et de 1,199 livres et 1,095 livres pour la variété tardive coupée aux mêmes dates.

Ensilage de maïs et moulée pour bouvillons

Seize jeunes bouvillons Hereford et Angus, nourris exclusivement à l'ensilage de maïs, en ont consommé 36 livres en

moyenne par tête et par jour. On leur en a fourni à satiété pendant 112 jours.

Pendant la même période, un autre groupe de bouvillons a reçu un même ensilage et de la moulée, à raison de 7 livres par tête et par jour. Ces derniers ont consommé 22 p. cent de moins d'ensilage que les premiers. Cependant, les bouvillons recevant l'ensilage seul ont consommé 7.8 livres de matière sèche totale par jour, comparé à 12.5 livres pour ceux à l'ensilage et à la moulée. Le gain journalier et la quantité de matière sèche par livre de gain furent de 0.77 et 11.0 livres pour les bouvillons à l'ensilage seul, et de 1.9 et 6.6 livres pour ceux à l'ensilage et à la moulée.

Croissance de bouvillons en rapport avec les normes alimentaires

Des bouvillons récemment sevrés, pesant 450 livres et hivernés selon les normes recommandées par le Conseil National de Recherches (E.U.A.) réalisèrent un gain journalier moyen de 1.19 livre par tête. D'autres bouvillons semblables, soumis à des régimes de 15 p. cent au-dessus ou en dessous des normes recommandées, ont fait, durant la même période, des gains de 1.39 et 0.88 livres respectivement. L'indice moyen de consommation, exprimé en livres d'éléments nutritifs totaux par livre d'accroissement de poids, augmenta avec la libéralité des régimes. La différence d'indice de consommation entre les plus hauts régimes et le plus bas fut significative.

L'addition de graisse animale à la ration d'hiver, à raison de 0.25 livre par tête et par jour, augmenta le poids pendant l'hiver, mais n'eût aucune influence significative sur la croissance durant l'été suivant, au pâturage.

Engraissement des bouvillons à l'herbe

On a maintenu des bouvillons antenais à raison de 0.75 tête et 1.5 tête l'acre sur quatre pâturages de 11 acres chacun, dont deux étaient à dominance de Ladino et deux à dominance de mil. Le parc de Ladino où il y avait 0.75 tête a reçu 500 livres de 0-15-30 l'acre; celui de mil ayant la même charge de paissance a reçu en plus 400 livres de nitrate d'ammoniaque. Là où il y avait 1.5 tête l'acre, les niveaux de fertilisation ont été le double des précédents. On a fait pâturer en rotation et on a récolté le surplus d'herbe sous forme d'ensilage.

Les pâturages de trèfle Ladino ont produit moins de matière sèche que ceux de mil, soit 8,156 livres à l'acre en regard de 10,050 livres. La production totale d'herbe sous forme de matière sèche a très peu différé d'une fumure à l'autre parce que, sur les pâturages à 0.75 tête, on a récolté un plus grand surplus d'herbe à un stade de maturité plus avancé que sur les parcs à 1.5 tête. La saison de paissance fut de 149 jours sur les pâturages de Ladino et de 161 jours sur ceux de mil.

La production de bœuf a été de 203 livres à l'acre pour les fumures normales et de 348 livres pour les fumures massives, soit une augmentation de 71 p. cent. La production de bœuf a été plus considérable sur les pâturages de mil (83 p. cent) que sur ceux de Ladino (53 p. cent). Les bouvillons ont fait un gain journalier plus élevé sur les parcs de 0.75 tête que sur ceux de 1.5 tête. Enfin, il a fallu 19 livres de matière sèche pour produire 1 livre de gain sur les pâturages de mil fortement fertilisés, comparé à 16 livres sur les autres pâturages. Le rendement moyen des carcasses a été de 53.0 p. cent pour les bouvillons engraissés avec le Ladino et de 51.6 p. cent pour ceux engraissés avec le mil. Le classement a été le même dans les deux groupes. La capacité de charge n'a pas influencé le rendement mais elle a faiblement favorisé le classement.

Valeur comparative de trois pâturages de graminées

Trois champs de graminées, mil, pâturin et dactyle, ont été pâturés en rotation par des brebis. Tôt le printemps, on a épandu 500 livres de 10-10-10 et, à la mi-juillet, 200 livres de nitrate d'ammoniaque à l'acre. Sur chacun d'eux, la mise à l'herbe a eu lieu entre le 20 et le 27 mai et les brebis ont quitté les parcs à la mi-octobre.

Les quantités de matière sèche produites par le mil et le pâturin ont dépassé les 6,400 lb/a tandis que le dactyle a fourni en moyenne 5,500 livres. Le pourcentage d'utilisation a dépassé 95 p. cent.

L'augmentation de poids des brebis a été plus élevé avec le mil qu'avec les deux autres graminées. Ainsi le mil a produit, en 1966, 225 livres de gain à l'acre et en 1967, 302 livres, en regard de 183 et 204 livres pour le pâturin et de 127 et 187 livres pour le dactyle. Les capacités de charge du mil et du pâturin ont été de 7.8 brebis à l'acre en moyenne et celle du dactyle de 5.8 brebis. Le nombre de jours-brebis a été dans le cas du mil et du pâturin, de 1,140 et 1,195 et chez le dactyle de 840.

Comparaison de progénitures de béliers Suffolk et Southdown

Au cours de l'hiver 1966, on obtenait deux béliers Southdown, type «Punch-bowl», de la Nouvelle-Zélande. Parce qu'ils étaient plus lourds et de conformation différente, on décida de comparer leur progéniture à celles de deux béliers Southdown et de deux béliers Suffolk canadiens.

En collaboration avec la Station de Recherches de La Pocatière, on a accouplé les six béliers à des brebis croisées Suffolk × Leicester. Des 169 agneaux ainsi obtenus, 86 furent abattus au poids d'environ 45 livres, et 76 au poids de 90 livres. Les descendants des Southdown canadiens atteignaient le poids de 45 livres environ 10 jours plus tard que les autres. De plus, ils pesaient 90 livres environ 15 jours plus tard que les agneaux des Southdown de Nouvelle-Zélande, et 25 jours plus tard que ceux des Suffolk. Cependant, ces derniers étaient moins bien finis et avaient une plus forte proportion de la carcasse dans le quartier avant que les agneaux des béliers Southdown.

PHYTOTECHNIE

Influence du stade physiologique sur la productivité et la composition chimique des graminées

Le mil Climax et le brome Saratoga ont été récoltés au cours du premier cycle végétatif à des stades bien déterminés: feuillu ou herbe, montaison, mi-épiaison, floraison et grenaison. Dans le deuxième cycle ou regain, des prélèvements ont été faits quand les plantes atteignaient à nouveau l'un des stades.

Au cours du premier cycle, le rendement du mil Climax qui, au stade feuillu, était de 1,579 kg/ha, est passé à 5,147 à la mi-épiaison 30 jours plus tard, pour atteindre 7,200 kg lors de la grenaison. Le brome Saratoga a manifesté la même tendance avec un rendement de 1,219, de 3,472 et de 6,160 kg/ha aux mêmes stades. Au cours du deuxième cycle les différences entre les rendements ont été assez faibles sauf dans le cas où la première coupe avait été faite au stade feuillu.

La production totale du mil pour la période mai à mi-septembre a varié de 3,970 kg/ha (feuillu) à 8,195 kg/ha (grenaison) et celle du brome de 3,980 à 6,765 kg aux mêmes stades.

Les matières azotées totales (protéines) (M.A.T.) du mil sont passées de 17.5 p. cent (feuillu) à 4.9 p. cent (grenaison) et celles du brome de 21.5 à 4.2 p. cent. La cellulose brute a augmenté avec l'âge de la plante. Les éléments P, K et Ca ont diminué au cours du premier cycle selon le degré de maturité des plantes sans distinction d'espèces. Si les matières azotées totales sont un indice de la valeur nutritive de l'herbe, la première coupe chez les graminées devrait se faire à la mi-épiaison alors que le rendement est satisfaisant et que les M.A.T. dépassent 10 p. cent.

Valeur des mélanges de graminées pour le foin

Le mil demeure, en mélange et en culture pure, la graminée la plus productive en régime de fauche. Pendant 3 ans, on a comparé le mil, le brome, le dactyle et l'alpiste roseau, en semis purs et en mélanges simples et complexes, au point de vue rendement de première coupe, vitesse de repousse et valeur des regains. Toutes les parcelles ont reçu chaque année une fumure complète et un apport d'azote après la première coupe. Dès la

mi-juin, au début de la floraison, on a récolté les mélanges à base de dactyle et les autres, à la fin de juin. Les regains ont été récoltés à la mi-septembre.

En culture pure, le mil a été la graminée la plus productive pendant 3 ans, mais en quatrième année il a été surpassé par l'alpiste roseau et le brome inerme. En mélange simple (deux graminées), associé au brome ou à l'alpiste roseau, le mil a toujours conservé sa supériorité. Le dactyle associé au mil a réduit de beaucoup les rendements de la première coupe, mais par contre, il a fourni les regains les plus élevés. En mélanges complexes (trois graminées), le mil, en présence du brome et de l'alpiste, a fourni de forts rendements. Cependant, ces derniers ont été inférieurs aux mélanges simples mil-brome et mil-alpiste de même qu'au mil en culture pure. La présence du dactyle dans les mélanges a encore contribué à diminuer la production de première coupe, mais elle a augmenté très légèrement celle des regains.

Établissement et productivité de certaines espèces fourragères annuelles

Depuis quelques années, on trouve dans le commerce des semences de sorgho, de Sudangrass et de leurs hybrides. Comme ces espèces sont peu connues dans les Cantons de l'Est, on a jugé bon d'étudier leur valeur agronomique.

Six hybrides sorgho × sudangrass furent comparés à l'avoine, au millet, et au maïs semé à raison de 200,000 plants/ha. On a cherché à déterminer les meilleures dates de semis en relation avec leur production; le potentiel de production en matière sèche lorsque les plantes sont récoltées au stade laiteux; et enfin, le rendement des variétés ou lignées de ces mêmes hybrides lorsque récoltés en vert c'est-à-dire à la montaison.

D'après les résultats de 3 années, on a pu établir: que la meilleure date de semis se situait autour du 1er juin; que le maïs semé à très forte densité (200,000 plants/ha) et récolté au stade laiteux donnait les plus forts rendements; et que le millet japonais donnait des rendements supérieurs aux hybrides ou à l'avoine, lorsqu'il était récolté à la montaison. On a aussi observé que certains hybrides sorgho × sudangrass ne sont pas encore suffisamment adaptés au climat local pour être préférés au millet japonais pour l'affouragement en vert.

Chou fourrager

Trois aspects sont à l'étude.

Variétés—Douze variétés de choux fourragers, dont neuf venaient de France et trois d'Angleterre, ont été mises à l'essai pendant 2 ans. En 1966, les rendements en matière sèche (M.S.) ont varié de 17,027 kg/ha pour la variété Giganta à 10,571 kg/ha pour Flamcaul. La M.S. brute digestible, calculée arbitrairement a été de 11,191 et 6,959 kg/ha pour les deux mêmes variétés. Les rapports feuilles:tiges ont été de 4.37 pour la variété Pastour et 0.39 pour Surmoël. En 1967, les rendements en M.S. ont été de 10,953 et 8,640 kg/ha pour Giganta et Cavarouge respectivement, et ceux en M.S. digestible brute de 8,055 et 5,013 kg/ha pour les mêmes deux variétés. Cependant, les rapports feuilles:tiges ont été moins élevés, puisqu'ils étaient de 1.63 et 0.28 pour les variétés Pastour et Surmoël.

Production et régie—En 1966 on a semé des choux fourragers du type mille têtes et du type moellier à des densités de 25, 50 et 100 graines au mètre dans des rangs espacés de 50, 75 et 100 cm. En 1967 on a appliqué deux doses d'azote, soit 80 et 160 kg/ha à du chou moellier semé à des densités de 50, 100 et 150 graines au mètre dans des rangs espacés de 50, 100 et 150 cm. Les résultats des 2 années ont indiqué la densité optimum à 100 graines au mètre, dans des rangs espacés de 100 cm, tant au point de vue rendement que rapport feuilles:tiges. On a aussi obtenu de très forts rendements avec un semis de 150 graines au mètre dans des rangs espacés de 50 cm; cependant, le rapport feuilles:tiges a été faible. Le type moellier a donné de meilleurs résultats que le type mille têtes. Les doses d'azote, qui ont varié avec les densités et les distances entre les rangs, n'ont pas montré de différence significative. Cependant, plus de 12 tonnes métriques/ha ont été obtenues avec une application de 160 kg/ha d'azote.

Contrôle des mauvaises herbes—Pour que la culture du chou fourrager puisse être promue, le contrôle des mauvaises herbes revêt une importance primordiale parce que la plantule ne peut les concur-

rencer et l'entretien devient trop dispendieux.

On a fait trois semis à 15 jours d'intervalle. Après chaque semis, l'herbicide 2-azido-4-isopropylamino-6-méthylmercapto-*s*-triazine de la catégorie des triazines a été appliqué en préémergence aux doses de 1.5, 3.0 et 4.5 lb/a du produit actif. Afin de mesurer l'effet de l'herbicide, les mauvaises herbes ont été prélevées deux fois, et les choux fourragers ont été récoltés les 21 et 25 septembre.

L'herbicide, tel qu'employé, a paru sélectif même au sein de la famille des crucifères. Il a bien contrôlé les mauvaises herbes à 1.5 et 3.0 lb/a et les a complètement éliminées à 4.5 lb/a. Cependant les meilleurs rendements ont été obtenus avec 1.5 lb/a. Il semble que la dose optimum se trouverait entre 1.5 et 3.0 lb/a.

Essais de variétés

Les résultats de ces essais servent à la préparation des listes de variétés recommandées dans le Québec.

Avoine—La variété Dorval, produite au collège Macdonald, a démontré une grande facilité d'adaptation à la plupart des régions du Québec. Sa forte productivité et la qualité de son grain en font une céréale de haute valeur alimentaire. À cause de sa maturité tardive, elle ne convient guère aux zones du Lac St-Jean et de la Gaspésie. Une autre lignée, tirée de la Shefford et produite par le Comité d'Amélioration de l'Avoine du Québec, se compare favorablement à Dorval et est fort prometteuse. Son rendement a été légèrement inférieur à Dorval, mais sa paille a mieux résisté à la verse et sa maturité est plus hâtive de 4 jours.

Orge—Les rendements constamment élevés de la variété Champlain en essais régionaux l'ont classée au premier rang comme orge de provende. De productivité légèrement inférieure, la Parkland est la variété toute désignée pour la production du malt; elle a supplanté la Montcalm par son rendement plus élevé et la force de sa paille.

Blé d'automne—En général, les variétés de blé d'automne se sont montrées suffisamment résistantes aux conditions d'hiver des Cantons de l'Est. Le séjour prolongé des plants sous une nappe de glace a causé plus de dégâts au peuplement que le manque de rusticité des variétés. Les variétés Richmond et Talbot se sont bien comportées.

Blé de printemps—Au cours de 1967, les nouvelles variétés Opal, Ring et la lignée Sask. 31 se sont révélées supérieures aux variétés plus anciennes Acadia, Selkirk et Cascade par leur productivité et leur résistance à la verse, mais non par la qualité de leur grain. Après 2 années d'essai, la variété Manitou se compare favorablement à la Selkirk au point de vue rendement, mais elle est de maturité plus tardive et produit un grain plus petit que Selkirk.

Seigle d'automne—Les variétés Horton, Sangaste, Dakold, Frontier et Antelope ont été éprouvées en 1967 et se sont montrées suffisamment rustiques. Le comportement de la variété Horton a été remarquable, sa paille a très bien résisté à la verse. Elle a donné le plus fort rendement et un grain de meilleure qualité de tout le groupe, mais le rendement en paille a été inférieur à celui de la variété Sangaste.

Colza—Deux types de navette furent mis à l'essai au cours de l'année: le type argentin (*B. napus*) et le type polonais (*B. campestris*). Les rendements des variétés et lignées du type argentin ont été de beaucoup supérieurs à ceux des variétés du type polonais. Il est bon de mentionner que les dégâts causés par les chardonnerets ont été graves chez le type polonais tandis qu'ils ont été négligeables chez le type argentin.

Lin—Parmi les 11 variétés à l'essai en 1967, Arny et Cree ont été les plus productives en même temps que les plus résistantes à la verse. En 2 ans d'essais, la variété Linott, produite par la Station de Recherches d'Ottawa, s'est classée première au point de vue productivité et maturité. La variété Norland s'adapte difficilement aux conditions locales à cause de sa maturation tardive.

Tournesol—Les lignées de tournesol, à l'essai depuis 3 ans, ont, de façon constante, démontré un potentiel de production supérieur aux variétés témoins. La production moyenne d'Armavirec a été de 1,472 livres et celle de Peredovik 2,006

livres à l'acre, tandis que les lignées CM90RR × Peredovik et CM2RR × (CM36 × CM37) ont produit respectivement 2,284 et 2,167 livres à l'acre. En 2 ans, la lignée CM323 × Peredovik a produit en moyenne 2,272 livres à l'acre comparativement à 2,094 livres produites par Peredovik et 1,608 par Armavirec.

SOLS

Plante-abri et fumure dans la rotation

En 1958, on a commencé une expérience où on étudiait les effets de la régie de la plante-abri (avoine) sur les rendements et la composition botanique des prairies. En plus, on tentait d'établir un programme de fumure adéquat pour une rotation de 4 ans, en variant les doses et les fréquences d'application.

Régie de la plante-abri—La fauche en vert de l'avoine n'a pas augmenté les rendements en foin des années subséquentes à l'exception de 1966 et 1967 où la production a été augmentée de 570 livres de matière sèche à l'acre. Cependant la fauche en vert a permis d'augmenter le pourcentage de légumineuses jusqu'à 60 p. cent comparé à 30 p. cent lorsque l'avoine était moissonnée à maturité. Cette influence ne s'est fait sentir que 4 années sur neuf et elle s'est atténuée très rapidement au cours de la troisième et de la quatrième année de rotation. D'où il ressort que la fauche en vert de l'avoine n'est pas une pratique agronomique très efficace. Là où la verse n'est pas à craindre, on ne devrait pas sacrifier une bonne récolte de grain dans l'espoir d'obtenir un meilleur établissement de légumineuses car les chances de réussir ne sont que de 44 p. cent.

Doses et fréquences d'application de fumures—Parmi les doses d'engrais chimiques, celle qui comportait 40 livres d'azote, 240 livres de P_2O_5 et 240 livres de K_2O a donné le plus fort rendement; soit 3.5 tonnes de foin à l'acre, comparé à moins de 2 tonnes sur les parcelles témoins. Une application annuelle de fertilisants s'est montrée supérieure à une fertilisation massive tous les 4 ans. La production de foin a été plus abondante et régulière, mais la production d'avoine a été plus faible.

Engrais chimiques versus fumier—Après 9 années d'essais, les engrais chimiques se sont montrés aussi efficaces que le fumier, pourvu qu'on utilise les mêmes quantités de N, P_2O_5 et K_2O dans les deux cas. La quantité totale d'éléments nutritifs à fournir au cours d'une rotation de 4 ans devrait être la suivante: 140 livres d'azote, 180 livres de phosphore (P_2O_5) et 240 livres de potasse (K_2O). Ces quantités devraient être distribuées annuellement de sorte que les plantes reçoivent au moins une fois par année assez de minéraux pour satisfaire leurs exigences.

Influence du pH du sol sur l'avoine

L'avoine semble supporter beaucoup mieux l'acidité du sol que ne le font la luzerne, le trèfle Ladino et le lotier. C'est ce qui ressort d'une série d'expériences destinées à déterminer l'influence du pH de divers sols sur les plantes de grande culture.

Rendements et pH du sol—L'action de la chaux sur la croissance de l'avoine a varié d'un type de sol à l'autre. Sur le sable St-Jude, les rendements en grain n'ont pratiquement pas été augmentés par le chaulage. Sur le loam Greensboro et l'argile Ste-Rosalie, une augmentation du pH des sols a amélioré les rendements de 35 à 25 p. cent respectivement. La courbe des rendements en fonction du pH a été presque linéaire chez le loam limoneux de Coaticook.

Interaction du phosphore et du pH du sol—Le chaulage a modifié le mode d'action du phosphore sur trois types de sol: le sable St-Jude, le loam Greensboro et le loam limoneux de Coaticook. Sur les deux premiers, l'accroissement des rendements attribuables au phosphore a été plus

fort en sol acide qu'en sol chaulé; le phénomène contraire s'est produit sur le loam limoneux de Coaticook.

Action de la chaux sur l'avoine et sur les légumineuses—En général, l'action de la chaux a été beaucoup moins grande sur l'avoine que sur les légumineuses. Par exemple, la luzerne n'a fait aucune croissance sur le loam Greensboro non chaulé tandis que dans les mêmes conditions, l'avoine a donné un rendement satisfaisant. Même le lotier a profité beaucoup plus du chaulage que ne l'a fait l'avoine. Il semble que cette céréale soit beaucoup plus tolérante vis-à-vis l'acidité du sol que ne le sont les légumineuses.

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[1] En congé d'études.
[2] Nommé en novembre 1967.
[3] Détaché auprès du Ministère de l'Agriculture du Québec sur un projet de ARDA.
[4] Nommé en mai 1967; en congé d'études.
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INTRODUCTION

Ce rapport constitue le premier compte rendu, depuis que la direction du Ministère a jeté les bases d'une nouvelle station de recherches sur le campus de l'Université Laval, au cours de l'été 1967. Pendant cette période, certains membres du personnel de la Station de Recherches de La Pocatière ont été transférés à Sainte-Foy, où la Faculté d'Agriculture a mis à leur disposition des bureaux, des laboratoires et autres facilités de travail, en attendant qu'ils puissent occuper leur nouvel immeuble.

Nous avons souligné, dans ce rapport, les résultats obtenus à la Station de Recherches de La Pocatière et ceux des fermes expérimentales de Normandin au Lac Saint-Jean, et de Caplan dans la Baie des Chaleurs. La Station de Québec devient le centre de recherches le plus important du groupe. Son directeur est responsable des programmes de recherches et de l'administration générale de ces établissements.

L'orientation des travaux se précise de plus en plus. L'élimination de certains bâtiments, maintenant superflus, à la suite de l'orientation nouvelle des programmes et le regroupement des autres en vue de faciliter les communications et le travail du personnel progressent normalement.

Champlain Perrault
Le directeur

LES ANIMAUX

Les bovins

L'épreuve de progéniture—En collaboration avec l'Institut de Recherches animales, la Station de Recherches de La Pocatière et la Ferme expérimentale de Normandin participent à l'étude sur l'hérédité des bovins laitiers. Cette dernière reçoit chaque année les jeunes taureaux des troupeaux Ayrshire des fermes expérimentales pour les épreuves de progéniture.

Les moutons

La progéniture de béliers Southdown et Suffolk—En collaboration avec la Station de Recherches de Lennoxville, on a comparé, à La Pocatière, la progéniture de deux béliers Southdown, du type «Punch-bowl», en provenance de la Nouvelle-Zélande, avec la progéniture de deux Southdown canadiens et de deux Suffolk. Les béliers ont été accouplés avec des brebis croisées Suffolk–Leicester.

Les agneaux provenant des béliers Southdown canadiens ont atteint le poids de 45 livres environ 10 jours plus tard que les autres. De plus, ils ont atteint le poids de 90 livres, environ 15 jours plus tard que les agneaux des Southdown de Nouvelle-Zélande et 25 jours plus tard que ceux provenant des Suffolk. Cependant, ces derniers étaient moins bien finis et avaient

[6] En congé de maladie depuis avril 1967.
[7] Nommé en mai 1967.
[8] Désigné en septembre 1967.

une plus forte proportion de la carcasse dans le quartier avant que les agneaux des béliers Southdown.

L'influence de la photopériodicité sur la reproduction des brebis—Depuis 1965, nous avons étudié, à La Pocatière, la possibilité de régulariser artificiellement la période d'activité sexuelle de la brebis en modifiant l'éclairement diurne. Trois cents brebis croisées et âgées de 3 à 5 ans ont été accouplées à des béliers Dorset Horn. La moitié de ces brebis étaient continuellement gardées à l'extérieur, tandis que les autres étaient gardées à la noirceur, à l'intérieur pendant le jour et au pâturage de 4 heures PM à 7 heures AM, dès le 1er juillet, lorsque les béliers ont été mis en service.

Chez les brebis soumises à une courte photopériode, 52 p. cent ont agnelé en décembre et janvier, tandis que chez les brebis gardées dans les conditions naturelles, à l'extérieur, 11 p. cent seulement ont agnelé en décembre et janvier.

LES PLANTES

Les plantes fourragères

Le trèfle Alsike—La première pousse des lignées de Prince-George et Odenwald ont encore rendu plus que Aurora et la semence commerciale. Elles ont même fait mieux que le trèfle rouge. Nous avons sélectionné pour leur vigueur des plants parmi les plus tardifs dans les pépinières plantées avec la lignée de Prince-George.

Le trèfle blanc—Pour la première fois en 10 ans, les dommages causés par l'hiver, à La Pocatière, ont permis de classer les variétés de trèfle blanc en trois catégories. Les variétés Regal et Espanso de même que Ladino certifié de Californie n'ont survécu qu'à 25 p. cent, tandis que Nordic et Nora n'ont à peu près subi aucun dommage. À la suite des dommages dus à la gelée, les variétés Merit, Pilgrim, Tillman et Ottawa sont les Ladinos qui ont le mieux rendu. Aucune des nouvelles introductions de 1967 ne s'est révélée supérieure à Pilgrim et à Merit parmi les Ladinos ni à Nordic parmi les trèfles de type intermédiaire.

Le lotier—Parmi les variétés hâtives, Dawn a dépassé Viking au début de la saison à La Pocatière. Wallace a rendu aussi bien que Léo à la première coupe et a donné un meilleur regain. Après plusieurs années d'essai, il semble difficile d'implanter le lotier dans la région de Normandin.

Une étude de plusieurs lots de semence de différentes variétés a révélé que la grosseur de la graine variait beaucoup à l'intérieur d'une même variété, tandis que le poids sec des tiges et des racines de plantules, de même que le rapport tiges-racines étaient constants, pour la même variété, peu importe la grosseur de la semence. L'étude des plantules sous des conditions artificielles a permis d'identifier le mode de croissance des plantes. Un essai a démontré que la photopériode est le principal facteur qui accentue la différenciation. Le différentiel de température entre le jour et la nuit est moins important.

La luzerne—Les récoltes de 4 années consécutives ont démontré, à La Pocatière, le manque de persistance des variétés A-9-H, Du Puits, Europe et Orchésienne. Un autre essai de 3 années a montré le peu de persistance de Cody, Orchésienne et Progress. Cependant, plusieurs des nouvelles introductions de 1967 sont très prometteuses, si l'on en juge par leur rendement en première année de semis. À Normandin, les variétés Glacier, Rhizoma et Alfa ont donné les meilleurs rendements. Rhizoma s'est montrée la mieux adaptée, cependant, elle est plus tardive que les deux autres variétés.

L'action résiduelle des graminées

On a comparé l'effet résiduel de quatre graminées cultivées pendant 5 ans en paissance simulée en utilisant l'orge comme plante indicatrice. Ce sont les parcelles, antérieurement en mil, qui ont donné le meilleur rendement d'orge; le pâturin lui était légèrement inférieur et le dactyle a laissé le moins bon effet résiduel. Les rendements de l'orge n'ont

pas manifesté de corrélation avec l'humus (quantité et qualité) ni avec la stabilité des aggrégats déterminés avant son ensemencement.

Les céréales

L'avoine—Deux sélections, O.A. 18-28 et Q.O. 117.7, ont donné de bons rendements et un grain de bonne qualité à Normandin. La variété Dorval s'est montrée productive, mais il reste à déterminer si notre saison de végétation lui permet d'atteindre une maturité suffisante.

La variété d'avoine Orbit, introduite de l'état de New York pour sa résistance à la verse, n'a pas donné les résultats escomptés à La Pocatière. Une lignée du groupe du Québec, Q.O. 19-27-1, s'est révélée résistante à la verse et bonne productrice. Plusieurs lignées d'avoine introduites du Manitoba n'ont pas versé, mais leur paille cassait facilement. Les introductions de Weibull ont manifesté une excellente résistance à la verse, mais leur rendement a été moyen.

Un croisement a donné plusieurs sélections qui ont bien rendu et on a pu sélectionner, dans un autre croisement, une lignée très résistante à la verse mais possédant peu de qualités agronomiques.

L'orge—La nouvelle variété Galt a été égale à Champlain dans les essais de La Pocatière. Dans les essais préliminaires, un croisement du groupe du Québec a donné une sélection très résistante à la verse et un bon rendement. Dans les essais plus avancés d'élimination, un autre croisement a produit trois bonnes sélections dont l'une résiste à la verse.

Parmi les variétés à deux rangs, Zephyr et Impala, introduites de Hollande, ont rendu plus que Herta. Impala, surtout, a une paille forte. Les deux variétés n'ont montré aucun charbon nu, tandis que l'introduction IB 6-3 s'est révélée très susceptible.

Le blé—La variété Opal et une sélection de Weibull ont très bien rendu. Quatre introductions de France n'ont pas dépassé la moyenne en rendement, mais trois d'entre elles avaient une excellente paille.

Cinq variétés de blé semées au même taux ont rendu mieux en rangs espacés de 9 pouces que de 6 pouces. En rangs espacés de 6 pouces le taux de semis de 1 minot/acre a rendu autant que celui de 1.5 minots.

Les céréales d'automne—Les variétés de seigle Sangaste et Frontier ont donné les meilleurs rendements de grain, mais Frontier a produit moins de paille. Les rigueurs de l'hiver ont permis de faire plusieurs sélections, tant dans le seigle que dans le blé.

Une forte infection de blanc a démontré la résistance des blés d'automne Talbot et Genesee à cette maladie.

Les plantes oléagineuses

Le lin—Après 6 ans d'essai, les variétés Redwood et Norland se sont montrées les plus productives en graine et en huile. Toutefois, elles ont l'inconvénient d'être tardives. Parmi les variétés hâtives, Linott a dépassé Marine et Raja en production de graine et en pourcentage d'huile.

Le colza—De 1962 à 1967, la variété Tanka s'est montrée supérieure aux autres variétés du type *Brassica napus* L. Des variétés hâtives du type *Brassica campestris* L., Echo et Arlo ont donné un rendement sensiblement égal, mais supérieur à celui de Polish. Dans ce dernier groupe, Arlo s'est avérée la variété la plus précoce avec une teneur en huile un peu plus élevée.

Les fruits et légumes

Le framboisier—À Normandin, les variétés Killarney et Boyne se sont mieux comportées que la variété Newburg, et la sélection M-541 s'adapte bien à cette région lorsqu'elle est plantée dans un sol approprié.

Le maïs—Parmi les variétés de maïs à l'essai à La Pocatière, Seneca doré, Spancross amélioré et Sunny Vee ont donné de bons rendements. À Normandin, Spancross et Seneca 60 se sont montrées les mieux adaptées à la région. La variété Régal des Jardins (Garden treat), semée pour la première fois dans la région, est aussi précoce et aussi productive.

Le pois—Les variétés de pois verts Supersweet et Onward ont nettement dominé les autres en rendement à La Pocatière, tandis que la sélection de pois secs 7608-6C2 a donné de bons rende-

ments à Normandin tout en possédant de bonnes qualités culinaires. La variété Stirling n'est pas adaptée à la région du Lac Saint-Jean.

Le désherbage chimique des pois secs—Le trifluralin et le Balan utilisés en pré-semis aux taux respectifs de 1.12 kg/ha (1 lb/acre) et de 1.68 kg/ha (1.5 lb/acre) ont été très efficaces au cours d'un essai de 2 ans. La prometryne appliquée en pré-levée au taux de 3.36 kg/ha (3 lb/acre) a aussi donné de bons résultats. Dans cet essai de pois, dominaient *Chenopodium album* L., *Echinochloa crus galli* (L.) Beauv. et *Setaria viridis* (L.) Beauv.

Le haricot—À La Pocatière, toutes les variétés de haricots ont donné de bons rendements; les variétés Cherokee Wax et Contender étant légèrement supérieures. Chez les haricots secs, aucune nouvelle variété n'a rendu plus que Clipper.

Le rutabaga—Dans un essai d'une durée de 6 ans, à La Pocatière, la variété Angus, d'origine écossaise, a donné un rendement supérieur de 11 p. cent au rendement moyen des huit autres variétés. Ditmars et Laurentien se sont montrées aussi productives l'une que l'autre.

L'influence de la date du semis sur le rendement du rutabaga—Durant une période de 5 ans, on a semé des rutabagas les 23 et 29 mai et le 7 juin chaque année. Les rendements ont été respectivement de 81.29, 74.37 et 60.37 tonnes métriques/ha ou 36.28, 33.19 et 26.94 tonnes/acre.

Le désherbage chimique—Le R-1607 et le trifluralin employés en pré-semis et incorporés aux taux respectifs de 4.48 kg/ha (4 lb/acre) et 1.12 kg/ha (1 lb/acre) se sont avérés les plus efficaces désherbants. Au cours d'un essai de 4 ans, ils ont détruit respectivement 88 et 79 p. cent des mauvaises herbes sans affecter la récolte. Les principales mauvaises herbes étaient: l'échinochloa pied-de-coq, *E. crus galli,* le chénopode blanc, *C. album,* et la renouée persicaire, *Polygonum persicaria* L. Le R-1607 a été supérieur au trifluralin pour la destruction du chénopode.

La pomme de terre

Parmi les semis hâtifs sous observation en divers endroits du Québec, F5647 se compare avantageusement avec la variété Irish Cobbler par son rendement, sa précocité et son excellente qualité culinaire. Parmi les semis tardifs, F5570, issu de Fredericton comme le précédent, donne un rendement supérieur à ceux de Green Mountain et de Kennebec, et produit des tubercules de bonne apparence et de bonne qualité culinaire. Le semis F5994 produit des tubercules d'excellente qualité et à fort rendement en terre organique. Ce semis ainsi que F5570 seront recommandés à l'homologation en 1968.

Cultivés en sol très favorable à la gale commune, les variétés Huron, Cherokee et Norland et les semis de Fredericton F5748, F5752, F6210, F6267, F6309, F6327, F6375 ainsi que quatre haploïdes sont résistants à cette maladie. Le semis Wash. 48-1 est aussi très prometteur sous nos conditions.

Le désherbage chimique des pommes de terre—Un essai conduit durant 4 ans a démontré que l'EPTC et le R-1607, appliqués au taux de 4.48 kg/ha (4 lb/acre) et incorporés immédiatement avant la plantation, pouvaient réprimer environ 90 p. cent des principales mauvaises herbes soit *E. crus galli, C. album* et *Spergula arvensis* L. La prometryne employée au taux de 3.36 kg/ha (3 lb/acre), après le buttage, a détruit 84 p. cent des mêmes mauvaises herbes.

PHYTOPATHOLOGIE ET PHYSIOLOGIE

La flétrissure bactérienne,
Corynebacterium sepedonicum
(Spieck. & Kotth.) Skapt. & Burkh.

L'épreuve de la résistance—Seulement huit solanacées et sept hybrides interspécifiques, la plupart possédant 24 chromosomes (2N-24), étaient exempts de bactéries après inoculation des racines. Huit haploïdes (2N-24) de la variété Saranac, éprouvés de la même façon, n'ont pas

montré de résistance. Les variétés Merrimack, Urgenta, Erie et Saranac étaient exemptes de symptômes après inoculation des tubercules ou des racines, tandis que les variétés Furore et Teton ont produit, respectivement, 1 p. cent et 3 p. cent de tubercules avec symptômes. Quatorze des 17 semis du Maine et les semis F8020 et F8215 de Fredericton n'ont pas manifesté de symptômes après les deux méthodes d'inoculation. Les nouvelles variétés américaines Monona et Peconic sont sensibles au flétrissement bactérien.

La désinfection du couteau—La décontamination du couteau par trempage rapide dans SC1210, dilué à 200 p.p.m. et dans Kem-Germ dilué à 5 onces par gallon, a donné une récolte de tubercules apparemment sains. L'examen microscopique des empreintes prélevées des tubercules indiqua que la récolte était exempte de bactéries après trempage du couteau contaminé dans la solution de Kem-Germ. Cet ingrédient chimique apparaît donc comme l'un des meilleurs désinfectants du couteau pour réprimer cette maladie. La décontamination des éclats de tubercules dans des solutions de même nature a été inefficace.

Les méthodes diagnostiques—L'examen microscopique d'empreintes faites à la base des tiges, aux stolons et au talon de chaque tubercule d'une même plante, à divers stades de croissance, indique que les empreintes faites à la base des tiges, après 60 et 70, 80 et 90 jours de croissance, constituent un meilleur critère que les empreintes faites aux stolons et aux tubercules. Après 100 jours de croissance, l'une ou l'autre des trois méthodes a permis de déceler l'organisme de la flétrissure de toutes les plantes infectées.

L'effet des fertilisants—L'apport d'engrais chimique complet, à raison de 2,000 livres à l'acre, a eu pour effet de marquer sensiblement les symptômes de la flétrissure sur le feuillage, notamment durant le mois d'août. L'addition de 200 livres d'azote à l'acre dans le sol sablonneux Saint-Pacôme a masqué les symptômes sur le feuillage sans affecter les symptômes sur les tubercules, tandis que la même quantité d'azote sur un sol très pauvre de la Côte Nord a eu pour effet de masquer totalement les symptômes sur les tubercules.

La fertilisation des pommes de terre maintenues en solutions hydroponiques a montré qu'une déficience en azote, en phosphore et surtout en potassium affaiblit les plantes, diminue le poids frais, le diamètre et la hauteur des tiges et augmente la sensibilité à l'infection. L'effet des déficiences est plus prononcé sur les plantes infectées que sur les plantes saines.

L'effet des facteurs écologiques—Les variétés Merrimack, Saranac et les semis B725-61, B3478-23 et Wy1122 n'ont montré aucun symptôme de flétrissement aux différents endroits où elles ont été produites, tandis que la variété Teton, à La Pocatière, et Erie, sur la Côte Nord, ont eu respectivement 4 et 72 p. cent de leurs buttes dont les tubercules montraient des symptômes à la récolte. Cependant, les trois semis déjà mentionnés étaient porteurs de l'organisme pathogène sur un sable pauvre de la Côte Nord, tandis qu'ils en étaient pratiquement exempts sur le sable Saint-Pacôme. Ces résultats indiquent que le sol et le climat influent sur la manifestation des symptômes de cette maladie aussi bien que sur la croissance de l'agent pathogène dans la plante.

La nutrition aminée de C. sepedonicum—Différentes combinaisons d'asparagine-méthionine-leucine, en milieux synthétiques, ont démontré que seule la méthionine est essentielle comme source de soufre organique à la croissance de *C. sepedonicum* et qu'elle ne peut être remplacée par la cystine, seul autre aminé soufré libre chez la pomme de terre. Une trace de méthionine, soit 10 à 20 p.p.m., suffit en présence de l'asparagine ou de la glutamine à assurer une bonne croissance de l'organisme. Certains composés aminés tels que la sérine, la glycine, l'éthanolamine et la cystine diminuent la croissance bactérienne.

La tache argentée, *Helminthosporium solani* Dur. et Mont.

Les façons culturales, la désinfection du sol et des tubercules de semence se sont avérés des moyens inefficaces dans la répression de la tache argentée et démon-

trent bien l'importance de la semence comme source d'infection. L'emploi de semence entièrement libre de ce champignon pathogène demeure le seul moyen efficace d'enrayer cette maladie. Une semence saine peut être produite par le bouturage ou le marcottage des cimes de tiges de pommes de terre. Des tubercules ainsi produits étaient exempts d'infection après 2 mois d'incubation dans une chambre à température et humidité constantes.

L'examen de 3,216 buttes de pommes de terre a révélé que le pourcentage de buttes gravement contaminées par la tache argentée (infection de 90 à 100 p. cent des tubercules) est beaucoup plus élevé lorsque les éclats de semence sont tous infectés que lorsque très peu ou pas le sont. Ceci démontre une fois de plus l'importance de la semence comme source d'infection et laisse supposer que le sol lui-même ne saurait être foyer d'infection que dans la mesure où il contient des débris de tubercules infectés.

L'influence des facteurs environnants sur la morphologie de *Verticillium* spp.

L'étude des facteurs environnants capables d'influencer la morphologie de *Verticillium* spp. a démontré que les milieux de culture, leur âge et leur pH ainsi que la température n'affectent pas la longueur des conïdies. Par contre, l'analyse de variance a démontré que les milieux de culture et leur âge affectent significativement la largeur des conïdies, tandis que la température et le pH du milieu de croissance n'influent aucunement sur ce caractère.

La pourriture des graines de luzerne

Des essais poursuivis en serres avec *Trichoderma viride* Pers. ex Fr. et *Gliocladium roseum* (Link) Bainier ont démontré que ces deux organismes envahissent les téguments séminaux de la luzerne et les font pourrir, diminuant ainsi le pourcentage de survivance des graines. La luzerne inoculée avec ces microorganismes a, après 21 jours, un poids sec significativement moins élevé que la luzerne non-inoculée utilisée comme témoin.

L'action du chlorure de chlorocholine sur la luzerne et les céréales

L'addition du chlorure de chlorocholine (CCC), sans aucun endurcissement au froid, n'a pas sensiblement modifié la croissance feuillue ni la floraison de la luzerne, mais a donné une augmentation du poids des racines, a permis une plus grande accumulation des réserves et une croissance plus abondante à la noirceur; la différence a été plus grande pour la variété Alfa que pour Vernal. Après 2 semaines à la clarté, l'addition de CCC a favorisé la survie de la variété Alfa seulement.

Lorsqu'on a substitué du CCC au traitement d'endurcissement, la pousse à la noirceur a été en rapport inverse de la durée d'exposition à 3° C. Selon son taux de croissance à la lumière, la variété Alfa a survécu aussi bien 4 semaines après un traitement au CCC qu'après 4 semaines d'exposition au froid. Par contre, la variété Vernal s'est mieux comportée après 4 semaines d'exposition au froid qu'après tout autre traitement. La conductivité n'a pas révélé de différences appréciables de résistance au gel.

La verse a été très marquée sur les céréales sauf le blé dont la paille a été sensiblement raccourcie. Le CCC a faiblement mais régulièrement retardé la maturité de toutes les variétés de céréales.

LES SOLS

Le chaulage des sols à pommes de terre

Sur un sol dont le pH est inférieur à 5.2, la chaux est indispensable à la pomme de terre pour obtenir de bons rendements et des tubercules dont le poids spécifique rencontre les exigences de l'industrie de la transformation. Des expériences poursuivies en serre et en plein champ ont prouvé qu'on peut utiliser jusqu'à 2,000 livres de pierre à chaux sur le loam Saint-André et le sable loameux Saint-Pacôme sans provoquer le développement de la gale

commune. Sur la série Saint-Pacôme dont le pouvoir tampon est plus élevé que celui de Saint-André, la gale n'a atteint plus de 10 p. cent des tubercules qu'avec 6,000 livres de pierre à chaux. Sur la série Saint-André, il y avait généralement de 15 à 20 p. cent des tubercules affectés aussi bien avec 4,000 que 6,000 livres de chaux.

Le rendement moyen sur les deux sols comprenant plusieurs essais de serre et de plein champ a été 354 et 395 boisseaux à l'acre, respectivement, sur les parcelles-témoin et celles qui ont reçu 2,000 livres de pierre à chaux. Le poids spécifique de la variété Keswick est passé de 1.071 sur les parcelles-témoin (moyenne des deux séries de sol) à 1.080 sur celles qui ont reçu 2,000 livres de pierre à chaux, tandis que celui de la variété Montagne Verte est passé de 1.079 à 1.093. L'industrie de la transformation consent souvent des prix spéciaux à un produit dont le poids spécifique dépasse 1.085 et elle refuse généralement tout ce qui est inférieur à 1.075.

L'activité biologique des sols de l'Anse et de l'argile Kamouraska

L'analyse du loam argileux des sols de l'Anse comparée à celle de l'argile Kamouraska démontre que, dans les premiers, l'évolution du CO_2 est lente, le compte bactérien faible, et l'activité déshydrogénasique presque nulle. Ce sont là des indices d'un sol biologiquement inactif, d'où la lente décomposition et l'accumulation des matières organiques et sa fertilité réduite. L'argile de Kamouraska est également riche en matières organiques, mais à un taux moindre que les sols de l'Anse et l'activité biologique y est trois fois plus intense.

L'influence de la nappe d'eau sur les cultures

Cinq groupes de parcelles comprenant différentes productions végétales ont été établies pour étudier l'influence du niveau de l'eau sur la croissance et le rendement des cultures. Des nappes d'eau respectives ont été maintenues artificiellement dans trois groupes de parcelles à 48, 30 et 18 pouces de la surface du sol. Dans un 4e groupe on a maintenu des conditions d'égouttement naturel, tandis que dans un 5e groupe un drainage souterrain y maintenait la nappe d'eau naturelle entre 9 et 28 pouces.

Le rendement du mil et de la luzerne n'a pas été affecté par la profondeur de la nappe d'eau; celui du brome a été nul là où il n'y avait pas d'égouttement. Le rendement de l'orge a été directement proportionnel à la profondeur de la table phréatique.

L'APICULTURE

L'essaimage des abeilles

Le printemps frais de 1967 a retardé la période d'essaimage et l'essaimage artificiel a rendu sensiblement moins que la suppression de l'essaimage, à l'inverse des 2 années antérieures. Les migrations semblent être à l'origine d'une forte variation à l'intérieur de chaque traitement. L'emploi de cadres bâtis ou non-bâtis n'a pas modifié les rendements.

LES NOMS COMMERCIAUX ET LES FABRICANTS DE PESTICIDES MENTIONNÉS DANS LE TEXTE

Nom commercial	*Fabricant*	*Nom commercial*	*Fabricant*
Balan	Elanco Products Division, Eli Lily and Co. (Canada) Ltd.	Kem-Germ	Kem-San Products Ltd.
EPTC	Stauffer Chemical Co.	R-1607	Stauffer Chemical Co.
		SCL 210	Standard Chemical Ltd.

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Départs

E. G. Beauchamp, B.Sc. (Agr.), M.Sc., Ph.D. Démissionné en novembre 1967	Affinité entre les plantes et les sols
P. O. Roy, B.S.A. Retraité en octobre 1967	Régie des pommeraies

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INTRODUCTION

Ce premier rapport annuel résume les résultats des principaux travaux de recherches poursuivis en 1967. Le lecteur intéressé en trouvera un compte rendu plus complet dans les publications mentionnées à la fin de ce rapport. On peut se procurer des exemplaires de ces publications en adressant sa demande directement aux auteurs concernés ou à la Station.

L'objectif de cette Station est de poursuivre les travaux de recherches nécessaires à la solution des problèmes que posent la production et la protection des cultures horticoles (légumes, fruits et petits fruits) au Québec. Les tâches sont réparties entre des spécialistes appartenant à différentes disciplines qui travaillent individuellement ou en équipe, selon la complexité des problèmes à résoudre.

À la Station de Saint-Jean, on a complété en 1967 l'aménagement de huit nouveaux laboratoires et, à la ferme de L'Acadie, la construction d'une résidence pour le contremaître et d'un garage pour le remisage et l'entretien de la machinerie agricole. On a aussi parachevé le drainage sous-terrain de 70 acres.

A. A. Beaulieu
Le directeur

SOLS ET NUTRITION DES PLANTES

Fertilisants

Action de l'accumulation de fertilisants chez la pomme de terre—Chez cette culture, l'effet résiduel de l'accumulation des fertilisants dans un sol organique persiste durant plusieurs années. Dans un sol où il y eut une application annuelle de fertilisants durant 5 années consécutives, le rendement de pommes de terre durant les 3 années subséquentes sans apport de fertilisants a été de 21.3, 19.6 et 9.9 tonnes métriques/hectare. Par contre, dans un sol témoin sans fertilisation au préalable, le rendement a été de 13.9, 16.5 et 6.2 tonnes métriques/hectare. Lorsque la fertilité du sol est déficitaire, le taux d'azote augmente progressivement et réduit d'autant les rendements de la pomme de terre.

Action des fertilisants chez les légumes—L'importance relative des éléments nutritifs majeurs pour certains légumes produits dans un sol organique bien décomposé a été l'objet de travaux de

recherches au cours des 3 dernières années. Dans un système de cultures successives, la potasse devient généralement le premier élément déficitaire. Ainsi, une application de 116 kg de potasse/hectare a augmenté les rendements du céleri de 29.26 à 44.71 tonnes métriques/hectare, ceux de la carotte, de 32.06 à 41.23 tonnes métriques/hectare, et ceux de la laitue, de 42.78 à 51.25 tonnes métriques/hectare. Cependant, des applications de phosphore n'ont augmenté d'une façon significative les rendements du céleri qu'après 3 années de récoltes successives. Par contre, les applications d'éléments nutritifs majeurs n'ont eu aucun effet sur les rendements d'oignons au cours des 3 années d'essais.

Le chaulage des sols organiques vierges et décomposés—De la chaux contenant 7 p. cent de carbonate de magnésium a augmenté considérablement le rendement de pommes de terre de la variété Kennebec produites dans un sol organique vierge et particulièrement décomposé. Une application de 6.75 tonnes métriques/hectare de chaux en plus de 56-56-112 kg de N, P, et K par hectare a augmenté les rendements de pommes de terre de 33.15 tonnes/hectare à 40.82 tonnes métriques/hectare. Sans l'application des fertilisants, la chaux seule, à raison de 27 tonnes métriques/hectare, a augmenté le rendement de pommes de terre de 19.32 tonnes métriques/hectare à 35.19 tonnes métriques/hectare.

En serre, le carbonate de sodium a modifié le degré d'acidité du sol et a favorisé la germination des graines de carotte; ce ne fut pas le cas avec le chlorure de calcium, employé à différentes concentrations. Ces résultats semblent indiquer que l'acidité du sol plutôt que la déficience en calcium était le principal facteur responsable du faible taux de germination de ces graines.

Interaction des fertilisants sur les semis de maïs sucré—Chez une variété hâtive de maïs sucré, Seneca 60, et une variété plus tardive, Seneca Chief, on a remarqué que leur réaction aux traitements d'engrais chimiques n'était pas influencée par la date de semis. De plus, la variété hâtive semée le 8 juin a donné un rendement beaucoup plus élevé que lorsque semée le 25 mai. D'autre part, les dates de semis ont eu peu d'effet sur le rendement de la variété tardive. Les deux variétés ont réagi aux traitements de fertilisants et le phosphore s'est révélé d'importance majeure.

Herbicides

Mode d'action des herbicides—Les dérivés de l'urée, tel le linuron, sont appliqués communément pour la répression des mauvaises herbes dans les cultures horticoles. Des essais faits en serre ont démontré que certaines espèces d'ombellifères sont plus résistantes au linuron que la carotte, culture où l'on emploie le linuron. Le coriandre, *Coriandrum sativum* L., en particulier, est très résistant à l'action du linuron et à celle des autres produits chimiques du même groupe. Il semble y avoir un double mécanisme d'action sélective chez ces produits qui est, d'une part, l'absorption et la translocation différentielles et, d'autre part, le taux différentiel de métabolisme des composés.

ENTOMOLOGIE

Bio-écologie

Tétranyque rouge du pommier—Les densités de population du tétranyque rouge du pommier, *Panonychus ulmi* (Koch), furent de deux à trois fois plus élevées en 1967 qu'en 1966. Par contre, l'ériophyide du pommier, *Aculus schlechtendali* Nal., avait diminué d'autant par rapport à l'année précédente et le tétranyque à deux points, *Tetranychus urticae* Koch, était pratiquement absent du verger. Ainsi, il devient de plus en plus évident qu'il existe une compétition réelle entre les acariens phytophages ou prédateurs.

Au cours de l'hiver 1966–67, la réduction ou mortalité des œufs d'hivernement de *P. ulmi* a atteint 85 p. cent dont 70 p. cent attribuable à des facteurs biotiques et

15 p. cent, à des facteurs abiotiques. L'activité prédatrice des typhlodromides et de certains autres acariens, observée principalement à l'automne et au printemps, s'est donc avérée très importante. Parmi les espèces présentes, il convient de noter *Typhlodromus rhenanus* (Oudms.) et *Balaustium* sp. Les facteurs abiotiques en cause furent principalement la glace, le verglas et la neige.

Malgré cette réduction importante des œufs d'hivernement, les populations estivales de *P. ulmi* atteignirent, vers la mi-août, des densités maxima de 125 œufs et formes actives par feuille. Ces populations, très élevées par rapport aux années précédentes, occasionnèrent une décoloration marquée du feuillage des arbres, la chute prématurée des pommes et furent génératrices d'un très grand nombre d'œufs d'hivernement observés sur l'écorce des arbres.

Au cours des six à sept générations de *P. ulmi,* en 1967, il a été établi que 70 p. cent des larves et des nymphes n'atteignirent pas le stade adulte. Les réductions, particulièrement importantes à partir de la troisième génération, furent attribuées à des facteurs biologiques, tels les typhlodromes, les arachnides, les pentatomides et les coccinelles.

Mouche de la pomme—L'éclosion des adultes de la mouche de la pomme, *Rhagoletis pomonella* (Walsh), débuta vers le 24 juin. Elle fut très abondante au cours des deux premières semaines de juillet, puis diminua graduellement pour cesser à la fin d'août. Cependant, des périodes de temps frais et pluvieux semblent avoir grandement entravé l'activité des mouches au début de la saison, de sorte que les premiers œufs ne furent observés que le 20 juillet et que le pourcentage de fruits attaqués fut plus faible que prévu chez les variétés hâtives. Par contre, les variétés McIntosh, Cortland et Fameuse se sont montrées très susceptibles aux attaques du ravageur et la Spy, plutôt résistante.

Dans la même parcelle, nous avons constaté la présence de deux Hyménoptères parasites des larves de cette mouche, les Braconides *Opius lectus* Gah. et *Opius alloeus* Mues., et de 29 espèces différentes de Coléoptères carabiques considérés comme prédateurs probables des pupes de cet insecte.

Chalcis de la pomme—La présence de cet insecte au Québec n'avait pas été signalée depuis 1935 mais, en 1967, elle fut observée dans plusieurs pommeraies du sud-ouest du Québec. L'importance du chalcis de la pomme, *Torymus varians* (Wlk.), peut facilement passer inaperçue du fait que ses attaques sont le plus souvent confondues avec celles de la mouche de la pomme. Cependant les adultes apparaissent un peu plus à bonne heure dans la saison que ceux de la mouche, soit vers le milieu de juin, et leur période de ponte ne dépasse pas la mi-juillet, tandis que celle de la mouche se prolonge jusqu'en septembre.

Cérèse buffle—En 1967, l'éclosion de quelque 1059 larves de la cérèse buffle, *Stictocephala bubalus* (F.), a débuté le 6 juin, a atteint son maximum d'intensité du 11 au 24 juin et s'est terminée le 1er juillet. Dès leur apparition, les jeunes larves ont quitté les pommiers pour s'établir en permanence sur les plantes herbacées dans le verger et plus particulièrement sur les plantes légumineuses. Le développement larvaire, déterminé par des élevages en insectarium, s'est échelonné du 6 juin au 31 juillet et a nécessité en moyenne 42 jours pour les mâles et 45 jours pour les femelles. La 5e mue, donnant naissance aux adultes, a pris place du 19 juillet au 31 juillet. La période d'oviposition a débuté le 10 août pour se terminer le 28 septembre. La fécondité moyenne de 19 femelles s'est établie à 113 œufs, tandis que leur longévité moyenne a été de 23 jours et celle des mâles, 21 jours.

Au cours de ces études, le chalcide *Polynema striaticorne* Gir., trouvé pour la première fois dans le Québec, s'est avéré un important parasite des œufs de la cérèse buffle. L'émergence des adultes de *P. striaticorne* a coïncidé très étroitement avec l'éclosion des œufs de la cérèse. Comme parasite des adultes, nous avons noté le nématode *Hexamermis* sp.; il s'agirait de la première mention d'un nématode s'attaquant à des Homoptères du genre *Stictocephala.*

Pyrale du maïs—Les données sur la dynamique des populations naturelles de la pyrale du maïs, *Ostrinia nubilalis* (Hübner), ont été complétées pour la génération 1966–67 et la réduction ou mortalité, évaluée tout au cours des développements de l'insecte, s'est répartie comme suit: stade embryonnaire, 11.3 p. cent; stade larvaire, 57.5 p. cent; stade nymphal, 0.7 p. cent et stade adulte, 29.4. p. cent. Ces résultats demeurent assez similaires à ceux obtenus au cours des années précédentes. Le taux total de réduction a été de 99 p. cent, ce qui est légèrement supérieur au taux de 98.6 susceptible de maintenir la population de l'insecte à un niveau constant. Les deux principaux facteurs naturels de réduction furent l'émigration larvaire qui a eu lieu après la récolte et avant l'hivernement ainsi que l'émigration des adultes. Depuis quelques années, nous avons pu noter qu'une forte émigration des adultes en juillet se traduit par une forte baisse de population à la génération suivante. L'indice du mouvement de la population fut de 75 p. cent impliquant ainsi une diminution de population à la génération 1967–68. En fait, la population initiale d'*O. nubilalis* estimée à 275 œufs par 100 plants en 1966 est passée à 206 en 1967.

Pour la première fois depuis le début de cette étude écologique, l'heure exacte de l'activité nocturne des papillons a pu être déterminée à l'aide d'un piège lumineux construit à cette fin. Du 4 juillet au 8 août, 354 papillons furent capturés principalement entre 9 heures PM et 1 heure AM et plus particulièrement entre 10 et 12 heures PM (Heure normale de l'Est). Les mâles, presque continuellement plus abondants, ont compté pour 67 p. cent du nombre total des captures.

Mouche de l'oignon—L'augmentation des semis d'oignon à l'acre n'implique pas l'accroissement du nombre de larves de la mouche de l'oignon, *Hylemya antiqua* (Meigen), par plant. Au contraire, un semis plus dense a favorisé sensiblement le parasitisme et l'incidence des maladies chez l'insecte et a créé de toute façon un milieu moins favorable à son développement qui s'est traduit par une perte de poids chez les pupes. Ainsi, à l'encontre des opinions déjà émises à ce sujet, les semis denses de la plante-hôte ne favoriseraient pas les pullulations de *H. antiqua.* Le taux des dégâts évalués à la récolte étaient plus élevés avec les semis denses mais demeuraient très inférieurs aux prévisions théoriques.

Faune entomologique dans les terres noires—À l'aide d'un piège lumineux muni d'un contrôle horaire, nous avons capturé, en 1965 et 1966, 10,739 spécimens d'insectes inféodés aux sols organiques dans le sud-ouest du Québec. L'identification et la classification de ces spécimens sont maintenant terminées. Ces captures représentent 345 espèces dont 50 p. cent appartiennent aux Lépidoptères, 47 p. cent aux Coléoptères et 3 p. cent à différents autres ordres. L'activité de ces insectes s'est révélée étroitement dépendante de la température; ainsi, les premières captures, en nombre très restreint, ont été obtenues à 35° F, tandis que les plus considérables ont été réalisées à 68° F. D'autre part, les moments de la nuit trouvés les plus favorables aux captures ont été de 9 heures à 10 heures PM et, à un degré moindre, de 1 heure à 2 heures AM (Heure normale de l'Est). Plus d'une centaine d'espèces collectionnées sont d'importance économique; on note plusieurs espèces importantes de vers gris, notamment *Feltia ducens* (Wlk.) et *Crymodes devastator* (Brace), des chenilles à tente du genre *Malacosoma,* le hanneton commun, *Phyllophaga anxia* (Lec.) et plusieurs espèces prédatrices de la famille des Carabidae.

Aphidologie

Comportement des pucerons—Les populations de certaines espèces de pucerons se manifestent dans la nature par des pullulations denses ou par des petits groupes dispersés dans le feuillage des plantes-hôtes. Cet aspect du comportement a été étudié à l'aide de la chambre d'essai mise au point pour les travaux relatifs aux couleurs. Dans ce cas cependant, chacune des six aires circulaires de 2.5 cm de diamètre est illuminée de la même couleur. Ainsi diverses espèces ont été libérées simultanément ou isolément en

vue d'étudier les phénomènes de cohabitation, d'attroupement et de densité des individus par unité de surface disponible. Le puceron du pois, *Acyrthosiphon pisum* (Harr.), exclut les autres pucerons de son aire de reproduction. Les associations des espèces *A. pisum* et *Macrosiphum euphorbiae* (Thos.), puceron de la pomme de terre, ou *A. pisum* et *Aphis fabae* Scop., puceron du haricot, ne peuvent se réaliser. Dans ces deux cas, chaque espèce habite son propre sachet. Par contre, les espèces *fabae* et *euphorbiae* cohabitent parfaitement en mélange sur les mêmes aires. Dans les essais comportant les trois espèces, il a été impossible d'observer des tendances réelles. Les associations libres des individus de même espèce ont démontré que *pisum* se répartit par groupes de 12 à 16 par sachet, *euphorbiae* par groupes de 5 à 8 par sachet. L'espèce *fabae* s'est groupée à la densité maximum des conditions expérimentales, i.e. 30 pucerons par sachet. Ainsi, il est intéressant de constater que les espèces de pucerons manifestent en milieu artificiel tout comme dans la nature leurs tendances au groupement ou à l'isolation, leur agressivité et leurs diverses densités de populations.

Nutrition des pucerons—L'acide éthylènediaminetétraacétique (EDTA) et ses sels dérivés de Na, Ca, Fe, Cu, Mg, et Mn ont été inclus dans diverses formules de diètes synthétiques. Des formules de solutions de sels utilisés dans la préparation de cultures hydroponiques de plantes ont été essayées pour suppléer aux carences minérales. Divers gradients de chelats de fer, calcium, magnésium et manganèse ont été essayés pour enrayer les effets toxiques de résidus de plomb provenant du sucrose. L'addition de FeEDTA a permis de maintenir en élevage le puceron de la pomme de terre, *M. euphorbiae,* durant huit générations successives. Toutes les autres tentatives se sont avérées infructueuses. Il apparaît maintenant très possible que sous peu les pucerons pourront être maintenus en élevages continus. Il s'en suivra des travaux nombreux sur la détermination des acides aminés essentiels.

Lutte chimique[1]

Tétranyque rouge du pommier—Des traitements préventifs appliqués contre le tétranyque rouge du pommier, *Panonychus ulmi* (Koch), au stade du bouton vert ou du pré-bouton rose des pommiers, les meilleurs ont été le tétradifon (nouvelle formulation, MeG249) et l'endosulfan-huile supérieure 70 sec. De plus, on a observé que deux applications à demi-dose d'éthion-huile, assurant vraisemblablement une meilleure couverture, étaient plus efficaces qu'une seule application à pleine dose.

Un traitement curatif effectué le 20 juillet sur des pommiers McIntosh a démontré que le Tranid, l'oxythioquinox et le Galecron étaient plus efficaces que le dicofol, le fenoflurazole et le tétradifon (MeG249) et ce malgré que le dicofol et le fenoflurazole furent appliqués une seconde fois le 7 août.

Des traitements curatifs sur des pommiers McIntosh effectués le 16 août, l'oxythioquinox, à dose moitié moindre que celle du Dessin et du chloropropylate, a assuré une répression deux fois meilleure que ces deux produits.

Des traitements curatifs effectués le 24 août sur des pommiers Lawfam, l'Azodrin a donné les meilleures résultats. Omite et Plictran ont été passablement efficaces, mais leur action s'est avérée plus lente.

En serre, sur de jeunes pommiers McIntosh, Plictran et N-4543 s'avérèrent plus efficaces que les autres produits à l'essai. Milbex a causé quelques brûlures au feuillage.

Mouche de la pomme—Contre la mouche de la pomme, *R. pomonella,* employé à raison de cinq traitements échelonnés du début de juillet au milieu d'août 1967, soit au cours de la période d'éclosion et de ponte intensives des adultes, le bromophos, le formothion, le Gardona, le GS-13005, le N-4543 et le phosalone se sont avérés aussi efficaces que l'Imidan et le carbaryl. Deux applications de diméthoate (Rogor) à 10 jours d'intervalle en juillet ont aussi donné des résultats comparables.

[1]Les noms des fabricants des produits dont la marque de commerce est mentionnée dans ce rapport sont colligés à la fin de ce rapport.

Chalcis de la pomme—Des essais préliminaires effectués en 1967 avec le DDT et l'Imidan appliqués le 16 juin n'ont pas fourni une répression adéquate du chalcis de la pomme, *T. varians*. En raison de l'apparition hâtive des adultes et de leur longue période d'éclosion, il semble que des applications de ces mêmes produits effectuées vers le 12 juin et répétées 10 jours plus tard pourraient être beaucoup plus efficaces.

Cérèse buffle—Après une deuxième année d'essais, des huiles minérales de type supérieur 70 sec., appliquées seules ou en mélange avec l'éthion au stade semi-dormant des pommiers, n'ont pas affecté sensiblement la survie des œufs de la cérèse buffle, *S. bubalus*. En effet, le taux d'éclosion dans les parcelles traitées a varié de 48 à 53 p. cent tandis que dans les parcelles-témoins il a été de 63 p. cent. La mortalité naturelle à ce stade de développement demeure donc assez élevée; le parasitisme causé par le chalcide *P. striaticorne* a affecté environ 14 p. cent des œufs dans les parcelles traitées et 18 p. cent dans celles non-traitées.

D'autres traitements insecticides contre les adultes de la cérèse buffle révèlent que le DDT, le carbaryl et le diazinon, appliqués le 11 août, ont réduit de 94 à 100 p. cent les populations de ce ravageur.

Mouche de l'oignon—Contre la mouche de l'oignon, *H. antiqua,* l'enrobage à sec de la semence d'oignon avec un mélange de diazinon, de thiram et d'une poudre adhésive a été plus efficace en 1967 et réellement plus économique que l'application de diazinon sous forme granulée dans le sillon. En fait, le traitement à sec de la semence a donné, à la récolte, une demi-tonne de plus à l'acre et son coût a été 20 fois moindre que celui du traitement dans le sillon. Quant à la réduction du taux de germination attribuable au diazinon, elle fut similaire avec l'un ou l'autre des traitements et sans importance économique appréciable.

Des observations portant sur la mortalité de jeunes plants d'oignon ont révélé que, dans les parcelles traitées, de 9 à 10 p. cent des plants étaient détruits par les maladies et autres facteurs, et pas plus de 4 p. cent l'étaient par les insectes; dans les parcelles-témoins, la mortalité due aux insectes variait de 33 à 42 p. cent et celle attribuable aux maladies et autres facteurs s'établissait à environ 28 p. cent. Comme ces mortalités surviennent au tout début de la croissance des plants, on mésestime trop souvent ces pertes.

Pyrale du maïs—La population de pyrale du maïs, *O. nubilalis,* fut très élevée dans tout le sud-ouest du Québec en 1967. Pour la première fois, la variété tardive de maïs fut plus attaquée que la variété hâtive. Dans l'ensemble, les traitements insecticides ont donné de 55 à 93 p. cent de répression larvaire. Chez la variété tardive, tous les critères biologiques relatifs à l'époque d'intervention se sont avérés très adéquats; par contre, chez la variété hâtive, seulement trois critères ont permis d'obtenir moins de 5 p. cent d'épis infestés; ce sont 15 jours après l'accumulation de 525 degrés-jours, 5 jours après l'accumulation de 700 degrés-jours et la date prédéterminée du 15 juillet. Pour le maïs tardif, il semble de plus en plus qu'une seule application, effectuée 15 jours après le début de l'oviposition, coïncide avec le maximum des pontes et permet ainsi de réaliser une répression adéquate et économique de l'insecte.

Concernant le nombre d'application, le DDT s'est avéré légèrement supérieur au carbaryl, mais le taux de répression n'a pas augmenté proportionnellement avec le nombre d'applications insecticides effectuées. Chez la variété hâtive, deux applications de DDT ont assuré une bonne protection, tandis que chez la variété tardive, une ou deux applications de carbaryl n'ont pas donné de résultats satisfaisants. Pour l'ensemble de ces essais, deux ou trois applications de DDT ou de carbaryl ont assuré de 75 à 95 p. cent d'épis sains.

Taupins—D'après des résultats antérieurs sur la répression des taupins (*Elateridae*) en sols organiques, les mêmes insecticides appliqués à l'automne se sont avérés plus efficaces qu'appliqués au printemps. Au cours des présents essais, tous les traitements ont donc été effectués au mois d'octobre 1966, tandis que leur efficacité relative à la protection des pommes de terre contre les taupins a été évaluée en octobre 1967. Les meilleurs produits, qui ont donné de 89 à 98 p. cent de tubercules vendables, sont l'aldrine, la dieldrine

et le bromophos sous forme d'émulsion ainsi que la dieldrine en poudre mouillable et le Dyfonate granulé. Les autres produits, qui ont donné de 84 à 87 p. cent de tubercules vendables, sont le bromophos et l'aldrine en poudre mouillable ainsi que le NIA 10242 et le SD 9098 sous forme granulée. Tous ces produits et quelques autres trouvés moins efficaces ont été appliqués à raison de 5 livres de matière active à l'acre et incorporés aux premiers 6 pouces du sol.

PHYTOPATHOLOGIE

Écologie

La racine noire de la betterave—Cette maladie, causée par *Aphanomyces cochlioides* Drechs., se développe à un rythme accéléré lorsque le degré de saturation du sol se maintient dans les environs de 70 p. cent et la température du sol près de 65° F. Ces mêmes conditions favorisent peu le développement de *Rhizoctonia solani* Kühn.

Résistance

Hernie des crucifères—Des 33 variétés et sélections de chou transplanté en plein champ dans un sol organique naturellement infesté de l'agent pathogène de la hernie, *Plasmodiophora brassicae* Wor., seulement quatre sélections ont montré de la résistance. La meilleure a été la F_1 d'un croisement des sélections 7-40 × 8-41. La F_3 de la sélection 8-41 (61-L-104) a aussi montré beaucoup de résistance, c'est un chou tardif à pomme ronde et ferme dont le poids moyen est de 3 livres.

Mosaïque du concombre—Sept variétés de concombre de table donnèrent l'indice suivant de susceptibilité croissante à la mosaïque, cucumis virus 1: Gemini, 0.077; High Mark II, 0.04; Exposition, 0.45; Palomar, 2.2; Challenger, 2.6; Long Marketter, 4.7 et Polaris, 5.1.

Gale du concombre—Les sept variétés de concombre utilisées au cours de l'essai sur la résistance à la mosaïque donnèrent l'indice suivant de susceptibilité croissante à la gale, *Cladosporium cucumerinum* Ellis & Arthur; Gemini, 0.00; High Mark II, 0.004; Polaris, 0.27; Challenger, 1.3; Palomar, 1.4; Long Marketter, 2.1 et Exposition, 2.3.

Racine noire de la betterave—Les quatre variétés de betterave potagère et les cinq variétés de betterave sucrière utilisées dans l'essai se classèrent dans l'ordre suivant de susceptibilité croissante à la racine noire, *A. cochlioides:* betteraves potagères: Reine Rubis, 3.4; Rouge foncé amélioré, 3.5; Rouge royal, 3.9 et Rouge foncé de Détroit, 6.3; betteraves sucrières: Polykühn, 0.66; Kuhn-R, 1.1; Monogerme, 1.7; H.C.-11, 2.1 et Cercopoly, 2.4. Les conditions microclimatiques ont été très favorables à l'activité de ce microorganisme.

Brûlure hâtive des tomates—Les six variétés de tomate utilisées donnèrent l'indice suivant de susceptibilité croissante à la brûlure hâtive, *Alternaria solani* Sor., qui s'est montrée modérément sévère: Heinz 1350, 0.06; 26-37-26, 0.12; $I_{10}S_6$, 0.26; F_3-30-S_3 et Manitoba, 0.30 et Sarfire, 0.41.

Races physiologiques—Des essais préliminaires furent effectués en serre pour déterminer les races physiologiques de la hernie des crucifères, *P. brassicae*, présentes dans le Québec; ceci afin d'apporter plus de spécificité dans les tests de résistance ainsi que dans les sélections et créations de variétés de chou résistantes à la hernie au Québec. Des 12 échantillons (chou et rutabaga) examinés, quatre étaient infectés avec la race 6 et trois avec la race 2 de *P. brassicae*. Les autres échantillons n'ont pas causé un degré suffisant d'infection chez les hôtes différentiels pour en déterminer la race avec certitude. Il est cependant possible qu'il y ait plus de trois races différentes.

Lutte chimique

Hernie des crucifères—Le diméthyle sulfoxyde (DMSO) fut utilisé comme véhiculant des fongicides Lanstan et quintozène dans le but d'accroître l'efficacité de ces fongicides à réprimer la hernie du chou, *P. brassicae,* en sols minéral et organique. Ces essais effectués en serre ont démontré que les fongicides Lanstan

et quintozène réduisent l'infection des racines de chou dans les sols minéral et organique inoculés avec l'agent pathogène de la hernie. En général, le quintozène s'avéra supérieur au Lanstan pour réprimer la maladie dans les deux types de sol. Le DMSO, incorporé au sol en présence du Lanstan et du quintozène, n'améliora pas l'efficacité des fongicides à prévenir la propagation de la maladie dans les sols minéral et organique. À forte dose (10,000 p.p.m.) le DMSO se montra phytotoxique tandis qu'à dose plus faible (1,000 p.p.m.) il favorisa la manifestation des symptômes de toxicité du manganèse sur les choux cultivés en sol minéral.

Racine noire de la betterave—Les fongicides Polyram et Dexon ont été utilisés seuls comme désinfectants de semence chez quatre variétés de betterave potagère et cinq variétés de betterave sucrière dans la lutte contre la racine noire, *R. solani,* et *A. cochlioides.* Les conditions microclimatiques en mars 1967 ont été beaucoup plus favorables à l'incidence de *A. cochlioides* que de *R. solani.* Le Dexon s'est avéré un bon protectant contre les infections sévères de *A. cochlioides* et les infections légères de *R. solani,* tandis que le métirame n'a réprimé, avec une certaine efficacité, que *R. solani.*

AMÉLIORATION DES PLANTES

Pommier

Essai de porte-greffes—Le rendement moyen en 1967 des pommiers McIntosh, Melba et Bancroft a été de 136 boisseaux à l'acre chez ceux greffés sur *Malus robusta 5* et de 94 boisseaux chez ceux greffés sur East Malling VII. Les dommages causés par le froid expliquent les faibles rendements de ces pommiers plantés en 1957.

Fraisier

Essai de variétés de fraisiers indexés—À L'Assomption, Qué., les fraisiers plantés en 1966 rapportèrent en 1967. Les moyennes des rendements à l'acre en livres furent:

Guards-man	Red-coat	Cava-lier	Mid-way	Poca-hontas	Earli-dawn
11,118	8,502	7,848	7,194	6,540	5,886

Les valeurs soulignées par la même ligne ne sont pas significativement différentes à 5 p. cent selon le test Duncan.

Framboisier

Essai de variétés de framboisiers indexés—Les framboisiers indexés plantés en octobre 1962 à L'Assomption, Qué., donnèrent leur quatrième récolte en 1967. Bien que la plupart de ces framboisiers aient été atteints de maladies virales depuis l'été 1966, leurs moyennes de rendements en livre à l'acre en 1967 furent:

Madawaska	Trent	Latham	Muskoka
10,459	9,519	8,363	7,857
Muskoka	Carnival	Comet	Tweed
7,857	7,109	7,037	6,435

Les valeurs écrites sur la même ligne ne sont pas significativement différentes à 5 p. cent selon le test Duncan.

Chou

Variétés et lignées résistantes aux insectes du chou—Les résultats de 2 années d'essais poursuivis en plein champ ont démontré que de 33 sélections et variétés commerciales, deux sélections, nommément W60 et W60-Al, et deux variétés commerciales, Early Marvel et Détroit Y.R. étaient résistantes à la mouche du chou, *Hylemya brassicae* (Bouché). De plus, la variété Red Acre aurait une certaine résistance ou serait moins attractive à la piéride du chou, *Pieris rapae* (L.), que les autres variétés ou sélections. Les données préliminaires indiquent aussi qu'il n'y a aucun rapport entre la couleur du feuillage et la résistance de la plante à l'insecte.

Régulateur de croissance

Essai de «Alar-85» sur pommiers—Des pommiers entiers des variétés McIntosh, Spartan, Cortland et Bancroft furent traités respectivement avec 1,000 et 2,000 p.p.m.,

les 20 juin et 15 juillet 1967. En 1966 les mêmes arbres reçurent les mêmes traitements sauf que le 19 août ils reçurent des applications de «Alar-85» à 1,000 et 2,000 p.p.m. Le 15 juillet 1967 les variétés Melba, Délicieuse dorée, Délicieuse rouge, Close, Atlas et Nume reçurent seulement 2,000 p.p.m. de «Alar-85». La variété Melba fut traitée de la même façon en 1966 et 1967.

Lorsque appliqué à la mi-juillet, «Alar-85» aux deux concentrations augmenta la coloration des fruits, retarda de 7 à 14 jours la tombée des pommes, augmenta la durée de conservation des fruits, empêcha grandement l'échaudure d'entrepôt sur la Cortland et rendit la Melba quasi annuelle dans sa production.

Essai de «Alar-85» sur fraisiers indexés—Des fraisiers indexés des variétés Redcoat, Sparkle, Cavalier et Guardsman furent plantés en mai 1966 à L'Assomption, Qué., et furent traités à raison de 1,000 et 2,000 p.p.m. de «Alar-85» les 21 juin, 13 juillet et 17 août 1966 et 1967. Ces traitements n'ont pas réduit significativement la production des stolons et ne retardèrent pas la cueillette des variétés Cavalier et Redcoat. Par contre, les traitements du 21 juin retardèrent de 2 et 4 jours la cueillette de la Sparkle et de 3 et 6 jours celle de la Guardsman. Les applications de la mi-juillet retardèrent la cueillette de la Sparkle et de la Guardsman de 1 et 3 jours. De plus, les rendements n'ont pas été significativement augmentés par les applications de «Alar-85».

Essai de «Alar-85» sur framboisiers—Des framboisiers indexés des variétés Trent et Latham plantés à l'Assomption, Qué., en 1965, furent traités en 1967 pour la deuxième année consécutive avec 1,000 et 2,000 p.p.m. de «Alar-85», le 21 juin, le 14 juillet et le 18 août.

Les applications de juin à 2,000 p.p.m. ont retardé considérablement la croissance des plants alors que celles de juillet n'ont presque pas affecté la croissance des plants. Les applications d'août 1966 ont retardé la croissance des tiges en 1967 ainsi que la période de cueillette des fruits. Le «Alar-85» aux deux concentrations a réduit de façon très significative le taux de tiges affectées par le froid surtout lorsque appliqué en juin et juillet. Les tiges traitées en 1966 donnèrent en général un peu plus de fruits en 1967 que celles non traitées.

LES NOMS COMMERCIAUX ET LES FABRICANTS DE PESTICIDES MENTIONNÉS DANS LE TEXTE

Nom commercial	*Fabricant*
Azodrin	Shell Chemical Company, Agricultural Chemical Division
Chloropropylate	Fisons (Canada) Limited
Dessin	Union Carbide, Olefins Division
Dexon	Chemagro Corporation
Dyfonate	Stauffer Chemical Company
Galecron	Ciba Compagnie Ltée
Gardona	Shell Chemical Company, Agricultural Chemical Division
GS-13005	Fisons (Canada) Limited
Imidan	Stauffer Chemical Company
Lanstan	Niagara Chemical Division, Food Machinery and Chemical Corporation
Milbex	Ihara Chemical Company Ltd.
N-4543	Stauffer Chemical Company
NIA 10242	Niagara Chemical Division, Food Machinery and Chemical Corporation
Omite	UniRoyal Limited
Plictran	Dow Chemical of Canada Limited
Polyram	Niagara Chemical Division, Food Machinery and Chemical Corporation
Quintozène	Olin Mathieson Chemical Corporation
SD 9098	Shell Chemical Company, Agricultural Chemical Division

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INTRODUCTION

The main research findings at the Research Station, Delhi, on the production of flue-cured tobacco are summarized for 1967. Progress was made in several areas of research, especially in plant breeding, soils and nutrition, maturity studies, disease and insect control, and the chemical constituents of the plants before and after curing.

An entomology section was added in 1967. The other sections are soil science, plant science, plant physiology, genetics

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and plant breeding, and plant pathology. Coordination among these sections is very important in the solution of interrelated problems on the highly specialized tobacco crop. Research facilities are being improved to more adequately direct field, greenhouse, and laboratory investigations aimed at producing greater returns, more suitable quality for both domestic and export markets, and fewer requirements for labor for growers. The research program includes any necessary changes that may be required in the quality of tobacco for manufacturing purposes.

L. S. Vickery
Director

SOIL SCIENCE

Fertilization

Potassium—The alkalinity of the ash and the ratio of Ca to K in flue-cured tobacco leaves decreased as the fertilizer K was increased from 60 to 300 lb/acre. The application of all of the K at planting time had a greater effect on the alkalinity and the ratio than when two-thirds was applied at planting time and the balance as a sidedressing 4 weeks later. Levels of applied K had no consistent effect on the burning rate of the tobacco.

Sulfur—The application of S at 1,000 lb/acre in September to sandy loam soils with a pH of 7.5 increased the soil acidity to an average pH of 6.0 by the end of the following harvest season. Lower rates of applied S increased the soil acidity to a lesser degree. Sulfur that was applied in the spring before plowing had no effect on soil pH by the end of tobacco harvest in the same year. Sulfur had no detrimental effect on the subjective quality of the cured leaves.

Soil Analyses

Minor element survey—Analyses of soil samples taken at 126 locations on 26 flue-cured tobacco farms scattered throughout the tobacco-growing areas of Ontario showed that exchangeable Mn ranged from 1 to 16 ppm, and easily reducible Mn ranged from 4 to 231 ppm. Mn, Zn, Cu, and Fe extracted from the soil with an EDTA solution varied from 4 to 244, 2 to 18, 2 to 74, and 48 to 232 ppm. The lowest values from Mn, Zn, and Fe occurred on the same farm, whereas the highest values for Cu and Zn occurred on another farm.

PLANT SCIENCE

Cultural Practices

Spacing and topping—In an experiment conducted over 3 years, the varieties Hicks Broadleaf, Delcrest, and Yellow Gold were planted at spacings of 20, 24, and 28 inches, in rows 42 inches apart, and topped to 14, 16, and 18 leaves. Topping to 14, 16, and 18 leaves had no consistent effect on K, total sugars, or the total sugars to nicotine ratio, but the yield and the dollar returns per acre increased and the grade index tended to decrease with an increased number of leaves. The closest spacing gave the highest yield every year, but gave significantly higher dollar returns in only 1 year. The effect of spacing on grade index varied from year to year. Wider spacing resulted in an increase in nicotine, N, petroleum ether extractives, total volatile bases, weight of ash, alkalinity of ash, K, and Ca in the leaves; and a decrease in total sugars and total sugars to nicotine ratio. Nicotine decreased with the number of leaves in each of 3 years;

N decreased with number of leaves in 1 year, but levels were unaffected by number of leaves in the other years. Levels of petroleum ether extractives, total volatile bases, weight of ash, alkalinity of ash, and Ca tended to decrease with number of leaves in 1 or more years.

Sucker inhibitors—Research was continued on chemicals for controlling sucker growth on tobacco. Emgard, methyl pelargonate, and Penar gave fairly good results as in previous years. In addition, several fatty alcohols that were tested showed promise in controlling suckers without causing much damage to the leaves. The average percentage of reducing sugars and the total alkaloids (ovendry) over a 3-year period for leaves treated with Emgard were 22.95% and 2.37%. Similarly, leaves treated with Penar had 24.52% and 2.24%, those with TSC350 (oil) 24.66% and 2.35%, and those hand suckered 21.90% and 2.61% of reducing sugars and total alkaloids. All chemical treatments produced a slightly higher yield per acre than oil-treated tobacco.

A number of tests were also conducted on private farms to observe the usefulness of chemicals for sucker control. Penar was applied on 100 farms and Emgard on 20 farms. In most cases both chemicals showed very promising results. Samples for chemical and physical analyses were taken on 45 farms.

Maturity Studies

Effect of maturity on quality—Smoking quality has been related to levels of specific chemical constituents or their ratios. Constituents or ratios, on a dry weight basis, considered ideal by manufacturers of cigarettes are as follows: total sugars (12–25%); nicotine (2.0–2.5%); total sugars to nicotine ratio (8:12); total volatile bases (0.34–0.44%); nicotine to total volatile bases ratio (5.8:6.6); nonnicotine volatile bases (0.14–0.20%); total nitrogen (1.5–2.3%); sand-free ash (14–16%); potassium to calcium ratio (0.75:1.0); chlorine (>0.7%); and petroleum ether extractives (6–8%). Samples of leaves harvested at various stages of maturity were chemically analyzed, and the results were compared with criteria of smoking quality. Leaves classified as slightly immature, mature, or slightly overmature were within the ideal range for six of the eleven criteria. These were total volatile bases, nicotine to total volatile bases ratio, nonnicotine volatile bases, total nitrogen, potassium to calcium ratio, and chlorine. All categories of maturity had satisfactory chlorine levels in 1 year in 2, lower than ideal levels of petroleum ether extractives each year, and optimum levels of nicotine each year. Based on levels of total sugars and sand-free ash, and on total sugar to nicotine ratio, leaves classified as immature or very immature were preferable to more mature leaves.

Culture of transplants—Studies on plants started in peat pots have shown that such plants are hardier and less susceptible to damage from disease, wind, and low temperatures than are seedbed plants. When insects are kept under control, little or no resetting is required. Such plants become established more rapidly in the field, grow more uniformly, and ripen sooner than seedbed plants. When peat pots are used, plant pulling and water are not required at transplanting time. Mechanical transplanters have been developed that handle peat pots satisfactorily. Small-scale production of peat-pot plants for replanting is considered worth while, because these plants become established quicker and ripen earlier than seedbed plants.

Plastic crop covers—Strips of clear plastic, 1 mil thick and 3 ft wide, were placed over young transplants to determine if such covers were of value in preventing frost or promoting early growth. Although no frost occurred after placement of the plastic, the night temperatures were higher in the areas covered by the plastic than in the uncovered areas. The transplants were undamaged after being covered for 11 days providing the covers were held above the plants on wire supports and there were ventilation holes in the plastic.

PLANT PHYSIOLOGY

Swelling of Mitochondria

Effect of ozone—Ozone induced rapid swelling of mitochondria isolated from leaves and roots of tobacco plants and increased the permeability of mitochondrial membranes. Reducing substances and substances with high molecular weight prevented, but did not reverse, O_3-induced swelling of mitochondria. Mitochondria underwent rapid contraction at acid pH, but this contraction did not prevent ozone-induced swelling. Although ozone promoted greater swelling at acid pH than at alkaline pH, the O_3-treated mitochondria were still responsive to acid-induced contraction.

Ozone primarily inhibited oxidative phosphorylation and respiration in tobacco mitochondria. The swelling of mitochondria, caused by a direct effect of O_3 on the structure of the mitochondrial membrane, would further decrease the phosphorylative activity of the mitochondria.

Effect of sucrose—Hypertonic solutions of sucrose neither induced mitochondrial contraction nor prevented O_3-induced swelling. There was a quick adjustment in swelling or contraction when the mitochondria were transferred from one to another concentration of sucrose, but in all cases O_3 induced further swelling. Apparently tobacco mitochondria did not behave as an osmometer in sucrose solutions and the preventive effect of sucrose on O_3 injury in tobacco leaves was not due to osmotic control of mitochondrial swelling. The results from previous experiments suggested a complex role of sucrose in the prevention of O_3 injury in tobacco leaves. Sucrose increased the phosphorylative activity in tobacco leaf mitochondria, prevented opening of stomata, and decreased the water-soluble nitrogen fractions that were related to leaf susceptibility to O_3.

Chemical Composition

Changes in leaf chemical constituents during growth—Changes in cultural practices in tobacco production and advances in technology have affected leaf quality through changes in physical and chemical properties. The effects of topping (removal of the inflorescence and two to four of the uppermost leaves) and close suckering (removal of all axillary buds 0.25 inch or less in length) on the accumulation of total alkaloids in the leaves were studied.

Tobacco that was permitted to develop normally showed a decreasing gradient in the percentage of total alkaloids from the base to the top of the plant. On the basis of dry weight, the leaves on the upper third of the plant contain less than 0.5% of the total alkaloids. Immediately after topping the total alkaloid concentration began to increase, and within 3 weeks total alkaloid levels were four times as high in topped as in nontopped plants. Close suckering resulted in a 68% increase in total alkaloids as compared with normal suckering (removal of axillary growth when 3–5 inches long).

GENETICS AND PLANT BREEDING

Inheritance of Quantitative Characters

Leaf length and width—A study of the mode of inheritance of length and width of the top, middle, and bottom leaves in a complete diallel cross test of eight flue-cured tobacco varieties showed that heritability values for leaf width were from moderately high to high (range 40 to 82%), and for leaf length from low to moderately high (range 27 to 57%), depending on the position of leaf on the stalk. On an average, the additive effects of the genes were more important in the upper leaves than in the middle or lower ones. It was concluded that progress in selection would be more rapid for leaf width than for leaf length, and for leaves higher on the stalk than for those lower.

Weather-fleck resistance—Four flue-cured tobacco varieties (White Gold, Hicks Broadleaf, Delcrest, and Florida 22) and a primitive strain T.I. 694 were

crossed to produce material for a study on the inheritance of tolerance to weather fleck, and to provide populations for selection. The mean rated values of the incidence of weather fleck in the first filial generation were higher than the midparent values in five out of six crosses, which suggests that susceptibility may be dominant over tolerance. Additivity was found important in two out of six crosses. Dominance determined by potence ratio was found important in five out of six crosses. It was concluded that quite a large number of generations would be needed to produce a weather-fleck-tolerant variety of acceptable type from the crosses studied.

Alkaloid levels—In a diallel-cross analysis with eight flue-cured tobacco varieties, values for both additivity and dominance relative to the total alkaloid content were significant and the mean degree of dominance was between zero and unity, which indicates partial dominance. Graphical analysis of the levels of dominance and recessiveness showed that two varieties (Coker 139 and Bissette 11), which were low in total alkaloid content, were in the area representing recessiveness. The diallel analysis was then continued for 7 × 7 and 6 × 6 systems by omitting the first and then both recessive varieties. It was found that omission of recessive varieties resulted in a decrease of the value for additivity and an increase in the mean dominance value. The additive portion of the genetic variance was considerably larger than the dominance portion. The establishment of homozygous lines that differ in total alkaloid level should be possible, provided that no difficulties arise from epistasis, linkage, and interactions between genotype and environment.

Mutations

Mammoth character—The agronomic values of a spontaneous mutation in flue-cured tobacco of the variety Delcrest, in which the day-neutral photoperiodic response of the parent variety was changed to short-day response, was tested under western Ontario conditions. The mutant, Mammoth Delcrest, yielded, on an average, more than the parent variety, and had a lower grade index, thinner leaf, higher filling value, and lower content of sugars and total alkaloids.

Black Root Rot

Interaction between age of seeding and inoculation rates—When root media were inoculated with the fungus *Thielaviopsis basicola* (Berk. and Br.) Ferraris from the third to the seventh week after seeding, the amount of infection was most severe at the earliest date in several varieties of flue-cured tobacco grown under controlled environment. First-generation hybrids of these varieties with Burley 49, which carries the *Nicotiana debneyi* Domin. immunity factor to black root rot, were infected by the Ontario isolate of the fungus if they were inoculated before 5 weeks of age, but were immune to the same isolate if inoculated at 5 weeks of age or later. Inoculation rates of 10,000, 50,000, and 250,000 spores/g of rooting media caused progressively more severe symptoms of the disease, in addition to reduced lateral root spread and decreased weight of vegetative growth. The interaction of varieties with rate of inoculum and time of inoculation showed that White Mammoth was more severely infected than other varieties at all rates on the three earlier dates of inoculation. When the experiment was terminated (9 weeks after seeding), the growth of all varieties was unaffected by inoculation at 7 weeks of age. Four weeks after seeding, inoculation caused less depression of growth with breeding line A34 than with five other varieties in the test.

Reaction of varieties to isolates of the black root rot fungus—Seedlings of five varieties and breeding lines of flue-cured tobacco grown in nutrient solution under controlled light and temperature were inoculated with nine isolates of the black root rot fungus, *T. basicola.* At 8 weeks of age, 2 weeks after inoculation with a spore suspension of 500,000 per seedling, breeding line P46A was significantly lower in disease incidence than the other four varieties. Lateral root spread in P46A, Yellow Gold, and Virginia Gold was significantly greater than in White Mammoth and Hicks Broadleaf. Three isolates of the fungus from Ontario and Quebec had similar effects on disease symptoms,

lateral root spread, and plant weight. However, these isolates were more pathogenic than two Kentucky isolates and one Virginia isolate. Two albino fungus isolates tended to be more pathogenic than their dark-type parental isolates.

Inheritance in Cigar-filler Tobacco

Heterosis in a diallel study—An F_1 diallel test with six varieties of cigar tobacco was conducted on a loamy sand soil to ascertain the potential genetic contribution of each variety for characters important in breeding cigar tobacco. Yield of cured leaf and topping height showed a positive heterosis for F_1 hybrids including Resistant Havana 211, Ottawa 705, and Low Nicotine 53. Resistant Havana 211 crosses showed a negative heterosis for grade index, which indicates that genes for high quality are recessive in the Resistant Havana 211 parent. Flowering was earlier in each F_1 than in the parental mean; in three of four crosses showing heterosis for this character, one parent was Low Nicotine 53. Pronounced heterosis for leaf length and leaf area was found in 10 of the 15 hybrids. Each variety, except Connecticut Havana 38, contributed genes for increased leaf size. Connecticut Havana 38 and Low Nicotine 53 contributed a dominance effect for reduced proportion of midrib to lamina. The duration of burn would appear to be under genetic control as the F_1 hybrids burned for a shorter time than the parental varieties. Levels of petroleum ether extractives were low in F_1 hybrids that included Resistant Havana 211 or Ottawa 705 as parents. Ottawa 705, which is fairly low in total alkaloids, showed a trend toward higher alkaloid content in its F_1 hybrids with other varieties. Nornicotine levels were quite high in F_1 hybrids that had Low Nicotine 53 variety as a parent, which shows the dominance for high nornicotine in this variety.

PLANT PATHOLOGY

Black Root Rot

Host susceptibility studies—The necrotic action of *T. basicola* endoconidia was tested on leaf disks of three *Nicotiana* spp. immune to black root rot, viz. *Nicotiana paniculata* L., *N. longiflora* Cav., and *N. debneyi,* as well as those of Burley 49, which is an immune variety of *N. tabacum* L. and on those of other crop plants. Leaf disks of *N. paniculata* had severe necrosis, and those of *N. longiflora* and *N. debneyi* had little or no necrosis. Burley 49 had considerably less necrosis than the susceptible variety White Mammoth. The necrotic action increased with concentration of spore suspension. Microscopic studies showed that the endoconidial germ tube penetrated the injured epidermal cells, and formed mycelium in the necrotic cells in the palisade layer or across the mesophyll. Such necrotic masses were formed with susceptible White Mammoth and to a lesser extent with immune *N. debneyi.* Seedlings of corn, oats, rye, wheat, and barley raised up to 50 days under greenhouse conditions, in either field-infested soil or sandy soil artificially infested at 2,000, 10,000 and 50,000 spores/g soil, were free from black root rot infection. When raised under the same conditions, cowpea and bean seedlings became infected in proportion to the amount of inoculum in the soil. Under humid conditions the endoconidia infected shoot fragments of tobacco, rye, oats, wheat, barley, corn, cowpeas, and beans. Within a few days the pathogen reproduced by forming chains of chlamydospores, which distintegrated readily into chlamydospores that were capable of causing infection.

Control

Soil fumigation—In the row, soil fumigation with Vorlex at 10 and 15 gal/acre, Vorlex 201 at 12 gal, and chloropicrin at 3, 6, and 9 gal checked the severity of black root rot infection, and reduced the population of the parasitic nematode *Pratylenchus penetrans* (Cobb).

Fumigation induced early maturation of tobacco plants. In addition fumigation of muck soil in the greenhouse with Vorlex, Vorlex 201, or Telone–PBC at 60 gal/acre significantly reduced natural weed infestation.

Pole rot—When harvested tobacco leaves were dipped in Allisan 50 (50% dichloran) suspension at 1 lb/50 gal water during curing, the incidence and severity of pole rot caused by fungi including *Rhizopus* sp. was reduced.

ENTOMOLOGY

Cutworm

Life history—From May to October, 1967, at Delhi, the dark-sided cutworm, *Euxoa messoria* (Harris), completed one generation in the field. Overwintered eggs hatched in the spring. Most of the larvae completed their feeding in late June and early July. From late July to mid-August the larvae pupated in the soil; and the adults emerged from early August to the end of October. The adults laid their eggs in the soil during this period. The eggs of the next generation completely developed before overwintering.

Growth of the larvae—The larval stage consists of seven larval instars. The number of larval instars determined during this study was based on the measurements of a random sample of 1,600 head capsules and on the numbers of molted skins collected by sifting sand from the individual rearing petri dishes.

Parasites—Four species of parasites, one chalcid and three Diptera, were reared from the cutworm prepupae and pupae. One species attacked the prepupae; the others attacked the pupae. The prepupal parasite and two of the pupal parasites developed internally in the host, and one developed externally on the host. All the parasites were classed as primary parasites of the cutworm *E. messoria.*

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Allisan 50	Boots Pure Drug Company
Emgard	Emery Industries (Canada) Ltd.
Penar	Pennsalt Chemicals Corporation
TSC 350	Pennsylvania Refining Company
Telone-PBC	Dow Chemical of Canada Ltd.
Vorlex	Morton Chemical Company
Vorlex 201	Morton Chemical Company

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Research Station
Harrow, Ontario

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[1] Seconded from Departmental Library.
[2] Transferred from Research Station, Kentville, N.S., in June 1967.

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INTRODUCTION

This report summarizes the research conducted during 1967. Detailed reports of completed research will be found in journals or reports listed under publications. Reprints are available from the authors.

Research on the white bean was reorganized and expanded. Dr. J. W. Aylesworth was made group leader and assigned responsibility for the breeding aspects. Dr. G. M. Weaver undertook an expanded investigation on the disorder

[3] Provided by Ontario Department of Agriculture and Food.

thought to be caused by ozone. Dr. J. H. Haas became responsible for disease investigations and Mr. H. B. Wressell was made responsible for insect problems.

Dr. R. P. Jaques, an experienced insect pathologist, has been transferred from the Research Station, Kentville, N.S., to this station. Because of the possible practical use of viruses and diseases in the control of certain insect pests of vegetables and field crops, we look forward to new approaches to insect control in the important commercial growing areas in southwestern Ontario.

The closing of the Entomological Laboratory at Chatham has resulted in the transfer to here of research related to field crops.

During the past year administrative and scientific as well as some supporting staff spent many hours planning the laboratories and other details for the proposed new building complex.

L. W. Koch
Director

FIELD CROPS

Corn

Corn leaf aphid—The first alatae were taken on April 26. Infestations on corn plants were seldom initiated by more than 1 to 3 alatae. Large variations in infestations observed when tassels became exposed were related mainly to the fate of the early alatae that entered the whorls. Some were killed by predators and parasites or left the plants after depositing 1 or 2 nymphs, but others deposited their full complement of young. In the latter instance, severe infestations were present at tassel exposure. The combined effect of aphid injury and low rainfall in 1967 resulted in low yields in many plots.

Culture—Row spacing – plant population – variety experiments for the third consecutive year showed that higher corn yields cannot be obtained from present hybrids planted in rows closer than 38 inches or at higher than the recommended plant populations of 18,000 – 20,000 plants/acre. The 1967 trial included commercial hybrids that are being promoted for higher plant populations in 20- to 30-inch rows.

Kernel red streak—In a series of single crosses between two classes of inbreds, one showing severe kernel red streak and the other showing very little streak, the crosses between resistant inbreds were highly resistant and those between susceptible ones were highly susceptible. However, susceptible × resistant hybrids ranged from highly resistant to highly susceptible, with the resistant parent usually exhibiting the greater effect on the performance of the progeny.

Root and stalk rot—The critical period during which stress irreversibly decreased kernel weight and predisposed the plants to stalk rot occurred sooner after silking than in previous seasons. Probably this was associated with competition for moisture in the unusually dry weather between mid-July and the end of September. Irrigation reduced stalk rot greatly in two resistant varieties, but only slightly in two susceptible varieties; without irrigation both the established resistant genotypes showed almost as much stalk rot as the susceptible ones.

Resistant inbreds developed greater stalk and leaf weights than susceptible inbreds. Resistant stalks were physiologically more vigorous in their early growth. Examination of dead cells in the pith during early growth did not always differentiate resistant from susceptible inbreds. Evaluation of the contribution to yield and stalk rot resistance from leaf distribution suggested that in a susceptible variety leaves below the ear played a minor part in the period during which stress is known to reduce kernel weight and to increase stalk rot.

Viruses of corn and cereals—The widespread occurrence of kernel red streak in southwestern Ontario due to the feeding of the eriophyid mite, which can transmit wheat streak mosaic, suggests that the virus could pass from corn to winter wheat in the autumn and back to corn during the

following growing season. In 1967, the virus was present in most fields of winter wheat in the Harrow area in the spring and again in November. Generally only occasional plants were infected, but in areas of two fields, infected plants were more frequent. In corn fields, the virus was not seen until August when occasional plants of corn or annual grasses were infected in 6 of 15 fields.

Soil-borne wheat mosaic was widespread in Essex and Kent counties in 1967. Symptoms diminished during the summer, but comparisons of samples from healthy and infected areas of each of four fields near Harrow indicated an appreciable yield loss when all the plants were infected.

Weed control—Sutan was the outstanding herbicide evaluated in 1967. Excellent control of annual weeds at harvest was obtained when Sutan was applied before planting and worked into the soil either in combination with atrazine or in a herbicide program where the atrazine was applied preemergence. CP50144 was the most promising new herbicide tested when combined with atrazine and applied preemergence on a sandy loam soil.

Corn and Soybeans

Physiology—A repetition of thinning trials on corn and soybeans confirmed that the mean Net Assimilation Rate (NAR) of corn plants growing in heavily thinned plots is nearly twice that of similarly treated soybean plants, but with increased plant populations the NAR of the corn declines more quickly than that of soybeans. The Crop Growth Rate (CGR) tends to level off at the higher levels of Leaf Area Index (LAI), but there is no clear indication of an optimum LAI at which CGR reaches a maximum value.

Complete fertilizer applied in moderate amounts before planting decreased the early growth and probably the percentage of germination of soybeans. Since phosphorus applied alone did not decrease growth or germination, the decreases are likely the result of the total concentration of salts in solution.

Oats

Two strains of oats, 5274-31-17 and 5276-3-9-4-99, were outstanding. In an advanced trial at Woodslee, they produced 104.5 and 101.5 bu/acre respectively compared with 94.3 bu/acre produced by Garry. The two strains also have short, strong straw and good kernel size.

Soybeans

Brown stem rot—Surveys of soybean fields in southwestern Ontario showed that brown stem rot, *Cephalosporium gregatum* All. & Chamb., occurred in 70% of the fields. An average of 60% of the plants showed symptoms of infection in these fields and 63% of the symptomless plants had the pathogen at the base of the stem.

Character evaluation—In a group of soybean varieties, heritabilities were higher for height, straw yield, and percentage of beans (proportion of bean weight to mature-plant weight) than for bean yield. Height, bean yield, and straw yield were negatively correlated with the percentage of beans. Height showed positive correlations with bean yield, straw yield, and maturity. Information on these characters will aid in selecting higher-yielding strains with earlier maturity and greater efficiency in production.

Daylength response—Extension of daylength with incandescent lighting delayed flowering of all varieties of soybeans. Extension of daylength with cool white fluorescent lighting greatly delayed flowering of some varieties (e.g., Harosoy 63) but not of others (e.g., Blackhawk). A genetic study of the progeny of Blackhawk × Harosoy 63 has shown that a major gene controls this response. Delayed flowering is completely dominant.

Weed control—Vernam applied before planting and soil incorporated stunted the growth of the soybeans and caused leaf puckering, which was evident until July. Both effects were more pronounced when Vernam was used with chloramben or linuron and to a lesser extent Patoran. The injury was accompanied by a significant reduction in yield of soybeans for the Vernam–chloramben and Vernam–linuron programs.

Burley Tobacco

Harvesting and curing—Extra-well-matured Burley leaves primed by hand, tied on sticks, and cured in an artificially modified atmosphere gave 25% higher yield per acre and 5.7% better grade value than stalk-cut tobacco cured conventionally with occasional supplemental heat. The yield per acre and the grade value of primed extra-well-matured leaves were also substantially higher in each of four different curing environments than leaves harvested at normal maturity, leaves from untopped and unsuckered plants, leaves from plants chemically suckered with maleic hydrazide, or leaves from plants with stalks girdled to advance maturity. A mean vapor-pressure deficit of about 0.27 inches of mercury for the whole curing period from August 18 to October 5 gave a grade value for cured leaves about 4% higher than for leaves cured at mean vapor-pressure deficits of 0.21 or 0.17 inches of mercury. Only extra-mature leaves cured at a mean vapor pressure deficit of 0.27 inches of mercury substantially exceeded stalk-cured leaves in grade value.

White Beans

Bacterial blight—The development of disease intensity was recorded in a 1-acre field of white beans, *Phaseolus vulgaris* cv. Sanilac, in which an epidemic of bacterial blight, *Xanthomonas phaseoli* var. *fuscans* (Burkh.) Starr & Burkh., was started. Sixteen days after planting, a 3-ft section of plants in the center of the field was inoculated. In the inoculated area, disease intensity reached 0.5 (50% leaf area with lesions) after 40 days and then remained constant. When half a leaf became infected, the leaf abscissed and thereby limited maximum disease intensity to 0.5. For the entire field, the disease intensity increased from 2.3×10^{-6} (10 days after inoculation) to 0.02 after 50 days.

Bronzing in white beans associated with air pollution—Concentrations of ozone as high as 9 pphm (parts per hundred million) have been detected during periods of sultry weather in mid-August in association with the incidence of the bronzing disorder of white beans in southwestern Ontario. Similar bronzing symptoms were induced by ozone fumigation of plants with concentrations as low as 8 pphm for 6 hr. This implicates ozone as the probable cause of bronzing in white beans.

Chemical protection against bronzing—Dusting of flowering bean plants, *Phaseolus vulgaris* L. cv. Seaway 65, with 5% ascorbic acid and 35% nickel dibutyl dithiocarbamate 24 hr before fumigation with ozone at 35 pphm for 1 hour provided complete protection against bronzing. These two compounds are effective antioxidants that prevent exposure of plant tissues to toxic levels of ozone by chemical recombination. The levels of ozone monitored in the test chamber during fumigation were reduced 31 and 54% respectively over that generated with control plant material.

Differential sensitivity of white bean cultivars to bronzing—Tolerance to ozone and the bronzing disorder it induces was observed in white and yellow-eye cultivars of *P. vulgaris*. Similar responses were obtained from progeny in hybridization studies where Clipper was the tolerant parent. Sensitivity was greatest in early-maturing cultivars especially Seafarer and Seaway 65. Ozone-induced abscission of developing bean pods was greatest in the same two cultivars, and pod losses of 14.6 and 22.0% were observed after natural occurrence of the disorder in the greenhouse. Continued hybridization and selection pressure from controlled ozone fumigation offers a promising approach to reducing the severity of the disorder.

Effect of bronzing on yield—The effect of bronzing on leaf senescence, pod weight, and final yield of white bean cv. Sanilac was measured after a natural occurrence of the disorder. During a 2-week period when defoliation caused by senescence normally occurs, slightly bronzed plants lost 62% and severely affected plants lost 88% of their leaves. At maturity, pod weight of the severely bronzed plants was 18% lower than the pod weight of the slightly affected plants. Seed yields of severely and lightly affected plants were 20 cwt and 23 cwt/acre respectively. Based on the growth rate of

pods during the season, it was estimated that slight bronzing reduced yields by 10%.

Winter Wheat

One of the strains under test, 4992H-221, produced an average yield of 69.6 bu/acre in tests at four locations. Genesee produced 65.4 bu/acre. The strain has good kernel size, quality, and stronger straw than Genesee. Yorkstar, a new short-strawed variety released from New York, produced only 58.1 bu/acre in the four tests.

HORTICULTURAL CROPS

Field Vegetables

Green Peach Aphid

Trapping—A program of daily trapping to record flights of vegetable aphids was started in 1967 to find out when new infestations are likely to begin and to identify the hosts from which the alatae migrate, which affects the numbers likely to carry virus diseases. There were two flight periods in 1967. Small numbers were trapped between May 26 and June 26. Alatae were seen leaving stem mother colonies on peach from June 1 to June 20 so the alatae that were trapped probably came from these colonies. Colonies first occurred on Brussels sprouts on June 15. These were probably from the first flight period. Large numbers flew from July 6 until November 10; the peak numbers occurred in August. Males flew from October 5 to November 4, and occurred in outside cultures from October 5 into December. Mating and egg laying occurred in these cultures.

None of the alatae from the first flight period had the enlarged foregut found in aphids feeding on Chenopod hosts, but a few from Chenopods occurred in the second period.

Although Borner's cornicle character, which is supposed to distinguish alatae from primary hosts, was found in alatae collected from stem mother colonies, it was also found in catches taken a long time after all alatae had left these colonies and even in alatae on Brussels sprouts in November. This character appears to be too widely occurring to be useful as a guide to host.

Muskmelon

Fusarium wilt of muskmelon—The duration of prewetting of muskmelon wilt soils with water influenced the effectiveness of formaldehyde, when applied as a drench against the wilt fungus, *Fusarium oxysporum* Schlecht. f. *melonis* Snyd. & Hansen. Formaldehyde was least effective in soils wetted for 24 hr before treatment and increasingly effective after 72 and 168 hr. Prewetting of soils did not affect the susceptibility of *Trichoderma viride* Pers. ex Fr. Man., *Penicillium* spp., and members of the *Mucoraceae* to formaldehyde.

Applications of formaldehyde that reduced populations of the wilt fungus to low values or zero did not consistently cause commensurate reductions in wilt. Pre- and post-amendments of these soils with ethanol showed that formaldehyde acted fungistatically at certain concentrations. The length of time soils were pretreated with ethanol also influenced the effectiveness of subsequent treatments of formaldehyde.

Partial to complete inhibition of growth of the muskmelon wilt *Fusarium* by substances that emanate from nonsterile soil was demonstrated under in vitro conditions. The antagonistic principle(s) readily diffuses through agar medium, and radially beyond the soil areas at room temperature and also at 4 C.

Interactions of fungi causing root rots in muskmelon—*Pythium ultimum* Trow, *Thielaviopsis basicola* (Berk. & Br.) Ferr., and *Verticillium dahliae* Kleb. are important soil-borne pathogens of muskmelon in southern Ontario. The first two cause root rot with accompanying aboveground symptoms, depending on the degree of severity of root rot. *V. dahliae* invades the plant via the roots without causing their necrosis; it colonizes the stem and

leaf tissues producing wilt, necrosis, and stunting of plant growth. Simultaneous inoculations with *P. ultimum* and *T. basicola* have caused injury indicative of an additive effect. With simultaneous inoculations of *P. ultimum* and *V. dahliae,* there is evidence of a reduced incidence of wilt caused by the latter. Low soil temperatures favored the aggressiveness of *P. ultimum,* but not that of *T. basicola* or *V. dahliae.*

Pythium root rot of muskmelon—P. ultimum was readily isolated from the necrotic roots of young and old muskmelon plants growing in soil in which sudden wilt had been severe. Muskmelons planted in steamed soils inoculated with *P. ultimum* developed necrotic roots and aboveground symptoms similar to those produced in naturally infested field soil. The fungus was considerably more pathogenic at low than at high soil temperatures. "Sudden wilt" was severe in growing seasons when long periods of abnormally cool weather occurred. It appears that *P. ultimum* plays an important role in the sudden wilt and crown wilt diseases of muskmelons.

Muskmelon variety trials—The commercial muskmelon variety test showed no significant differences due to yield or size of fruit. The new selections of the Station, H6401, H6402, H6403, and 0-1405BC4 equaled the Harper Hybrid in yield, and exceeded it in size.

Peppers

Control of green peach aphid—A 10% granular formulation of disulfoton applied to the soil as a side-dressing at 2 lb actual toxicant per acre gave a 97.5% reduction in aphids during an 8-week period when aphids were most abundant. Disulfoton was registered for use on peppers in 1967, but cannot be applied within 90 days of harvest. Residue studies indicated that a decrease in this interval might be feasible.

Insecticide residues—Residue analyses disclosed appreciable quantities of disulfoton metabolites in leaves but none in fruits, following preplanting soil application for control of green peach aphids. Therefore disulfoton can be safely used on peppers.

Pepper maggot—A study to compare maggot development in peppers and a wild host known as horse-nettle, *Solanum carolinense* L., was completed. Despite differences in host, time of attack, and the size of each stage of development, there was no evidence that two distinct host races had developed.

An average deposition of 41.6 eggs per female was obtained when flies were released in a large cheesecloth cage enclosing pepper plants in the field. This was the first instance in which the potential fecundity of the maggot was examined in nature.

Susceptibility to attack by insects—A continuing investigation of the varietal susceptibility of several types and varieties of peppers to the European corn borer, pepper maggot, and green peach aphid showed that the bell-type sweet pepper variety Keystone Resistant was the most susceptible to attack by the borer and maggot. All varieties appeared highly susceptible to attack by the aphid.

Tomatoes (Field)

Effect of root-knot nematodes on yield of tomatoes—A field of late tomatoes was infested with southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, for the evaluation of several commercial and experimental nematocides. The nematodes reduced yields by 10%. All treatments significantly improved the condition of roots. Plants in soil treated with Vorlex or metam-sodium were completely free of root galls. Temik was the only material that significantly increased yields.

Southern bacterial wilt in Ontario from Georgian transplants—Pseudomonas solanacearum E. F. Sm., the causal agent of southern bacterial wilt of tomatoes, was found in six fields of processing tomatoes in Kent County set with transplants from Georgia, USA. Infection ranged from 1 to 4% with only limited secondary spread occurring in two of the six fields. This is the first report of bacterial wilt of tomatoes in Canada where the origin of the transplants was known and the identity of the pathogen fully established.

Weed control—The use of herbicide programs gave superior weed control compared with single applications of the components of the programs. However, almost

all programs used injured the tomatoes. This effect was presumably the result of herbicide interactions because the components of the programs were not phytotoxic. The only programs safe for use on a sandy loam soil were trifluralin or Planavin followed by diphenamid. Safe programs on a clay loam soil included trifluralin followed by either chloramben or solan and chloramben followed by solan.

Potatoes

Verticillium wilt in potatoes and other vegetables—During 1967 extensive surveys of fruit and vegetable crops susceptible to verticillium wilt were made in Essex County to determine the incidence of wilt and the species of *Verticillium* involved. The crops sampled, the number of fields sampled, the number of fields containing infected plants, and the number of isolates obtained were: potatoes 76, 50, 109; tomatoes 40, 32, 87; peppers 20, 19, 66; muskmelons 19, 14, 36; eggplants 3, 3, 8; and watermelons 2, 2, 11. Of the 318 isolates obtained, 9 were *Verticillium albo-atrum* Reinke & Berth., 303 *V. dahliae*, and 6 *V. nigrescens* Pethybr. Isolates of *V. albo-atrum* and *V. nigrescens* were obtained only from potatoes. The ratio of isolates of *V. dahliae* to *V. albo-atrum* obtained from potatoes in 1966 was 4 to 1 and in 1967, 9 to 1.

In the aforementioned vegetables, symptoms of verticillium wilt were diagnostic only in eggplants and peppers. In tomatoes, potatoes, muskmelons, and watermelons a progressive yellowing and dying of the oldest leaves are symptoms of verticillium wilt, but these are also symptoms of other diseases.

In a replicated field experiment in which two lots of seed pieces from tubers (cv. Irish Cobbler from Prince Edward Island certified stock) were inoculated with spores and mycelium of *V. albo-atrum* and *V. dahliae*, the former proved to be highly virulent causing much wilting of foliage and premature death of plants. *V. dahliae* did not produce wilt symptoms, and general growth was not distinguishably different from that of noninoculated plants. *V. albo-atrum* was readily isolated from wilted plants during the growing season. In addition to infecting plants later in the season, *V. dahliae* did not colonize plants as extensively as *V. albo-atrum*. Yields in pounds from plots were: *V. albo-atrum*, 108; *V. dahliae*, 197; and control, 237.

In greenhouse pathogenicity tests, *V. albo-atrum* was consistently more pathogenic than *V. dahliae* to potatoes, tomatoes, muskmelons, and eggplants. Both species were more readily isolated from recently invaded tissues than from long-infected ones.

A recently elaborated technique for isolating *Verticillium* spp. from surface-sterilized infected tissues by plating them on moistened filter paper under aseptic conditions has made the identification of the species involved easier.

Greenhouse Vegetables

Cucumbers

Blossoms—Fruit production is directly related to the number of female blossoms appearing on a plant. The ratio of female to male blossoms is exceedingly sensitive to environmental conditions, particularly temperature and light. It has been shown that the ratio increases with the lengthening photoperiod from December to April. This effect can also be obtained by the judicious use of artificial light.

Crop protection—Tests of samples of two-spotted spider mite from commercial cucumber greenhouses produced no evidence of resistance to dicofol, naled, tetradifon, or oxythioquinox, materials in common use for several years. Although it is commonly assumed that naled is effective only against active stages of the mite, a high mortality of quiescent stages was obtained.

Oxythioquinox 25% WP applied as a slurry to greenhouse heating pipes at rates to give 3 to 4 oz active ingredient per acre was more effective when applied to newly deposited eggs of the greenhouse whitefly than to eggs ready to hatch. Residual effects from three applications, 10 to 12

days apart, totaling 11 oz active ingredient per acre were evident 1 month after the last treatment and produced 44% mortality of eggs and larvae. Eggs of the two-spotted spider mite were more susceptible than those of the greenhouse whitefly.

Fifteen materials were tested as residual contact sprays by placing two-spotted spider mites on treated leaves. Dicofol proved to be the most toxic to adults. When the same compounds were evaluated for population suppression, Animert V101, oxythioquinox, Galecron, and DuPont 1991 were as effective as dicofol because they prevented the spider mite eggs from hatching. Galecron was effective for 7 days after the last spray, but the other materials persisted at least 10 days.

Cultural practices—Supplementary light from mercury arc lamps, controlled automatically to produce a 15-hour photoperiod from January 15 to March 15, stimulated plant growth and increased the yield of marketable fruit by 20% over that obtained from nonilluminated plants. However, the mercury arc lamps caused severe, white necrotic spotting in young seedlings. This resulted in no permanent damage if the light was removed when the spotting began to appear, and mature plants did not appear to be susceptible.

Fruit development—A study of fruit ontogeny has shown that the percentages of nutrient constituents, N, P, K, Ca, and Mg are quite high in small, young fruits, but they soon decrease to values that are quite uniform regardless of the position of the fruit on the stalk, seasonal variation, or time of year.

Integrated control of pests—Two species of predacious mites were provided with excess numbers of two-spotted mites for prey, and the reproductive potential of the predators studied at several temperatures. *Phytoseiulus persimilis* Athias-Henriot had shorter generation times and laid more eggs than *Amblyseius fallacis* (Garman). Temperature greatly influenced the generation time of both species, and the time was minimal at 28 C. The intrinsic rate of increase at 26 C was about twice that at 20 C.

A number of chemicals applied as contact sprays to detached leaves were safe to adults of *P. persimilis* confined to the leaves after the spray was dry. The chemicals killed 90% of the two-spotted mite adults. Oxythioquinox and dicofol were selective in this manner at concentrations of 100 ppm. *P. persimilis* eggs were tolerant to acaricides and ovicides, and selective controls were found. Tetradifon and Animert V101 were harmless to predator eggs, but killed two-spotted mite eggs at concentrations down to 50 ppm. Dicofol was selective at 100 to 500 ppm, and oxythioquinox at 30 ppm.

Postplant control of root-knot nematodes—A split application of DBCP (Nemagon, Fumazone) in irrigation water controlled southern root-knot nematode, *M. incognita,* in an infected standing crop of greenhouse cucumbers. Treatment controlled juveniles in infested soil, but a second treatment was necessary to control juveniles that had remained viable in eggs in infected root tissue.

Cucumbers and Tomatoes

Joint action of phytopathogenic nematodes—The influence of the joint action of northern root-knot nematode, *Meloidogyne hapla* Chitwood, and root-lesion nematode, *Pratylenchus penetrans* (Cobb), on tomatoes and cucumbers was synergistic, it was greater than that of either species and exceeded the sum of the effects of the two species. Joint action had no influence on population dynamics. The same was true for the joint action of northern root-knot nematode and southern root-knot nematode, *M. incognita,* on lettuce. The synergistic effect was more pronounced at 30 C than at 25 C. Northern and southern root-knot nematodes exerted similar joint action on tomatoes in that the species had the same mechanism of parasitism and effects could be predicted from a knowledge of the individual species. The situation with cucumbers was more complex. Populations of northern root-knot nematodes decreased rapidly after several generations on this host. This was caused by a sex ratio favoring the development of males and correlated with the presence of small giant cells containing cytoplasm that was not as dense as that associated with northern root-knot giant cells in other hosts or

with cucumber giant cells caused by other species of root-knot nematodes. Because of this phenomenon, cucumbers may be used in combination with steam or a chemical fumigant for the control of northern root-knot nematodes.

Tomatoes

Bacterial canker of tomatoes—The bacterial canker pathogen, *Corynebacterium michiganense* (E. F. Sm.) Jensen, was infectious after 5 months' storage in plant debris at greenhouse or deep-freeze temperatures. It remained infectious in plant debris that weathered outside from November to March and remained infectious on clothing for 5 days. Suckering, topping, and handling plants with contaminated fingers were the most important means of secondary spread in the greenhouse.

Foliar trichomes as infection sites for bacterial canker—Foliar trichomes were particularly favorable sites for infection by *C. michiganense*. A direct relationship was established among leaf susceptibility, density of foliar trichomes, and leaf age. Injury during inoculation greatly increased the extent and severity of infection. Long, septate hairs with bulbous bases were infected with greater frequency than short or glandular hairs. Up to 65% of the lesions following leaf rub inoculation and 34% following spray inoculation were positively associated with trichomes.

Fruit development—The nutrient levels in developing fruit decreased as the fruit increased in size. The percentage of dry weight decreased, also the percentages of N, O, K, Ca, and Mg. In mature, ripe fruit, the nutrient levels were uniform.

Soil fumigation—In 1967, steam sterilization of greenhouse soils gave rise to slightly higher yields of tomatoes (cv. Michigan-Ohio in spring crop, and cv. Vinequeen in fall crop) than soils fumigated with Vorlex, and thus confirmed results reported previously. It was shown that the 1,3-dichloropropene and related chlorinated C_3 hydrocarbons component of Vorlex caused the reduction in yield, which was related to the somewhat slower early growth of the plants. In both spring and fall crops, plants growing in fumigated soil set an early heavy load of fruits and produced larger, earlier yields than plants growing in steamed soil. Earlier fruit development took place at the expense of satisfactory vegetative growth. Supplementary applications of $Ca(NO_3)_2$ and $NaNO_3$ did not adequately overcome the early season stunting effect of soil fumigation.

Variety trials—The greenhouse tomato variety tests, spring and fall crops, showed that four hybrids produced here and three varieties selected here for tobacco mosaic resistance produced the best yields and generally the largest fruits. However, the four hybrids lack somewhat in quality and the TMV-resistant varieties produced some plants in which virus symptoms appeared on the fruit late in the season, although no symptoms were evident on the foliage.

Tree Fruits

Apricots and Peaches

Bud hardiness as related to microsporogenesis—The relative hardiness of apricot and peach flower buds is significantly influenced by the stage of microsporogenesis, especially meiotic and postmeiotic stages. The greatest reduction in pollen viability occurred at the meiosis II stage of peaches and apricots. Changes in bud hardiness owing to varietal differences in the initiation of meiosis and rate of microsporogenesis are considered to be the main factors in the inconsistency of production of apricots and peaches.

Factors affecting cambium temperature in winter—Southwest exposure of trunks and scaffolds to direct solar radiation and prevailing wind resulted in excessive accumulation of heat compared to the NE side. Differences in heat accumulation were considerably reduced by application of white latex paint, which substantially reduced heat absorption from direct and indirect solar radiation. During one 24-

hour period, for example, the amount of heat accumulated above 0 C in degree-hours was 40.1 and 1.8 for SW and NE sides of an unprotected tree. Corresponding heat accumulations for a painted tree were only 0.7 and 0.0. During this same period the air temperature never exceeded 0 C. It was concluded that southwest injury caused by alternate freezing and thawing of bark tissues on trunks and scaffolds could be prevented by suitable paints.

Leachates from seeds as related to winterhardiness—A direct correlation was obtained between the established levels of bud hardiness of 16 apricot and 12 peach varieties and the electrical impedance of leachates from their seeds. Close inverse correlations were established between electrical impedance of leachates and optical density, dry weight, ash, and potassium concentration of leachates. Differences in seed-coat permeability between hardy and tender varieties was the chief factor affecting electrical impedance of leachates from seed. The seed leachate test was considered suitable in selecting hardier rootstock varieties.

Peaches

Activation of bark tissues with electric current to assess dormancy and winterhardiness—Activation of bark tissues of peaches for 20 sec with electric current generated at 50 v has provided an objective measure of the level of dormancy and winterhardiness. The basic method is a modification of that employed for similar purposes by the Central Genetical Laboratory, Michurinsk, USSR.

The measurement of activated potentials and subsequent decay at weekly intervals from November 8, 1966 through March 29, 1967 showed that hardy cultivars could be distinguished from intermediate and tender cultivars until February 7. Dormancy appeared to terminate at this time as measured by an increasing capacity of electrical potentials to resist rapid decay to a stable equilibrium. The hardy Siberian rootstock cultivar responded most rapidly to favorable temperatures in keeping with the anticipated behavior of this phenotype, viz. early tendency to enter fall dormancy is associated with a shorter chilling period and early resumption of spring growth. By contast, the cultivar Cardinal was most retarded in its response and maintained a continuous state of dormancy until March 21. It is pertinent to note that this cultivar, although bud tender, was selected in Georgia where mild, fluctuating temperatures are a continuous hazard. Consequently, this technique appears valuable in measuring the state and duration of dormancy in peach cultivars and it may be useful in predicting areas of adaptation.

Breeding—A series of promising peach varieties have been selected from extensive hybridizations involving Redskin, Earlired, Sunhaven, Dixired, J. H. Hale, and a Vineland selection, V37016 [(J. H. Hale × Vedette) × open]. These range in fruit maturity from extreme early to late season, beginning approximately July 10 with H129 and H177 and ending September 8 with H1620 and H2219. All are yellow-fleshed types selected for improved color, firmness, and quality by comparison with present commercial varieties maturing in comparable seasons.

Emphasis has been placed on increasing the winterhardiness of peaches to ensure more consistent productivity. Natural and controlled freezing studies have shown that the most of these promising selections have a level of flower-bud hardiness well in excess of Redhaven, the present medium-hardy standard. Two selections, H429, and H1748, show particular promise, since they combine winterhardiness with good fruit quality and appearance.

Crop protection—Orchard trials showed that combinations of malathion emulsifiable concentrate or wettable powder formulations with carbaryl wettable powder were compatible and equally effective against the lesser peach tree borer, *Synanthedon pictipes* (Grote & Robinson). Such combinations and trichlorfon were less effective than endosulfan.

Crown gall—Because the nature of infection of peach nursery stock by crown gall bacteria, *Agrobacterium tumefaciens* (E. F. Sm. & Towns.), in infested fields is not understood, the possible role of the root-lesion nematode, *P. penetrans*, and the northern root-knot nematode, *M. hapla*, as predisposing agents was investigated. In two different field soils rid of the natural flora and fauna by sterilization

then inoculated with crown gall bacteria alone and in combination with the nematodes, peach seedlings remained free from infection. In contrast, seedlings subjected to wounding by probing the crown and root with a sterile needle developed a high incidence of infection. Without needle wounding no crown gall developed. Though injury by the nematodes was clearly evident, obviously they do not provide a suitable infection court for the causal bacteria.

Electric impedance as a measure of winterhardiness in peaches—Electric impedance measurements on bark tissues of dormant peach scions shows promise as a technique for assessing varietal levels of winterhardiness. Significant correlation ($r = -0.7324$) has been established between impedance and established levels of flower bud hardiness, and varieties are consistent in their responses. High levels of impedance denote winterhardiness.

Application of this technique is limited, however, owing to the influence of two main variables, scion diameter and air temperature, at the time of measurement. Hence impedance values increase with a decrease in scion diameter ($r = -0.8580$) and with a decrease in air temperature. Natural and controlled freezing studies have shown that electric impedance measurements can be used effectively to establish the periodicity of flower bud hardiness. Winterhardy, intermediate, and tender cultivars can be distinguished at periods of maximum bud hardiness provided that thawed plant material (detached scions) is equilibrated for 1 hour before measurement at constant room temperature and that the influence of scion diameter is taken into account.

Although scion diameter was consistently associated with electric impedance in both juvenile and bearing peach trees, no significant correlations could be established in the juvenile stage of growth with known levels of winterhardiness. Consequently, the application of this biophysical technique appears to be limited to bearing fruit trees.

Insecticide translocation—Dimethoate, a water-soluble systemic insecticide, is translocated through peach trees in a uniform, steady manner. Disulfoton, a fairly insoluble systemic insecticide, moves in a very erratic fashion, although the speed of translocation of the two substances is similar. Dimethoate, therefore, is preferable where translocation is important.

Resistance to root-lesion nematode in rootstocks—Five rootstock cultivars, Harrow Blood, Rutgers Redleaf, Siberian, Elberta, and Lemon Free were evaluated for resistance to root-lesion nematode, *P. penetrans*. Seeds of each cultivar were germinated in steamed soil and in soils infested with three different nematode population densities. Elberta was the most susceptible. Lemon Free had a greater degree of tolerance to root-lesion nematode than any of the other cultivars.

Scion and rootstock cultivars influence scaffold crotch development in peaches—The angle at which scaffold limbs develop from the main stem of peach trees is influenced by both scion and rootstock cultivars. Measurement of 1,400 crotch angles for 48 cultivars disclosed significant differences. Angles ranged from 16° to 125° with a mean value of 47.05° for all cultivars. Wide-angle crotch formation was characteristic of Lemon Free, Collins, Valiant, Velvet, and Elberta, whereas Royalvee, Redskin, July Elberta, and the Babygold clings 5 and 8 differentiated a greater number of narrow-angle scaffold members.

The choice of rootstock cultivar also influences the size of the crotch angle. A significant reduction occurs with the propagation of early Elberta (Gleason) and Redhaven scion testers on the semidwarfing rootstock, Harrow Blood. Maximum crotch angle development occurred where Lemon Free was used as the understock.

Selection pressure to increase the development of wide-angle crotches would add considerably to the structural quality of peach trees as well as to lessen the incidence of winter injury and canker.

Weed control—Weed competition from July 1 to the end of the growing season reduced the growth of first-year trees by 39%. This competition also indirectly contributed to the observed 46% tree mortality in the weedy check plots by predisposing the trees to winter injury. In addition, weed competition caused significant reductions in tree growth of 2- and 3-year trees.

Weed competition, however, had no effect on the growth of 4-year trees.

Pears

Breeding for fire blight resistance in pears—Nineteen seedling progenies of known parentage were screened for resistance to fire blight. Of the 4,086 seedlings evaluated 33% were retained and 67% discarded. Only four combinations had more than 50% resistant offspring. Farmingdale, Maxine, and NJ 6 were the best sources of resistance.

SOIL SCIENCE

Soil Physics

Irrigation—The average yield of all corn plots irrigated throughout the season was 159 bu/acre. Where irrigation was discontinued at tasselling time the yield was 115 bu/acre and without irrigation 94 bu/acre. There was an interesting interaction between row spacing and soil moisture supply. Highest yields (170 bu/acre) were obtained with 22,000 or 28,000 plants per acre grown with full season irrigation in 20-inch rows. Without irrigation highest yield was produced by 16,000 plants per acre in 40-inch rows.

The yield of early tomatoes grown with a 7-day irrigation interval was almost identical with the yield if the irrigation interval was 12 days in June and 16 days in July as recommended in our irrigation schedules.

Lysimeter studies—Evapotranspiration from a corn crop grown with 16,000 plants per acre was equal to that where the crop was grown with 24,000 plants, provided soil moisture levels were kept high by irrigation. Yield was higher with 24,000 plants per acre.

In the absence of irrigation, soil moisture levels were quite low during much of the season and evapotranspiration from 24,000 plants/acre exceeded that from 16,000 plants. Also the lower plant population produced the higher yield and used less water.

Soil Fertility

Maintenance of soil fertility—Information on the amount of fertilizer required to maintain different levels of soil fertility would be useful if the optimum level of soil fertility for each crop was known. We have attempted to fit the yield data from three cycles of a 3-year rotation of tomatoes, cucumbers, and Burley tobacco to suitable response surfaces composed of the quantitative factors of fertilizer-P, fertilizer-K, soil-P, and soil-K. Of three models tested the inverse polynomial of Nelder accounted for the largest proportion of the yield variability in terms of soil and fertilizer variables.

The rotation of cucumbers, tomatoes, and tobacco was replaced by potatoes as the single crop. Tuber yields ranged from 80.5 to 189.4 cwt/acre. The soil P level required for maximum yield was tentatively estimated to be 506 lb/acre P. Potato yields were not closely related to the K level in the soil, although the addition of K to the fertilizer increased yields.

The fertility levels of three soils were reduced slightly by growing two consecutive crops of corn without P or K fertilization. In the third year P became deficient on Tuscola fine sandy loam limiting yield by 29.9 bu/acre. The maximum yield was 112.5 bu/acre on the fully fertilized plots. The deficient plots contained 64.7 lb/acre P and 91.3 lb/acre K as shown by soil tests.

MISCELLANEOUS

Control of Vegetable Diseases with Fungicides

Fifteen fungicides were evaluated in the greenhouse and in the field against one or more diseases attacking the foliage and fruits of tomatoes, cucumbers, muskmelons, onions, potatoes, celery, snap beans, and carrots. None of the newer fungicides was strikingly superior to several of the established fungicides. All eight fungi-

cides applied to carrots to control alternaria leaf spot reduced yield by 12% or more.

Dichloran Residue Analysis

A two-dimensional thin-layer chromatography method has been developed for the separation and detection of dichloran and its metabolites, a fungicide widely used on fruits and vegetables.

Insect Pathology

A project concerning diseases of insects was started at the Station in June 1967.

A field-plot test showed that numbers of larvae of the imported cabbageworm could be greatly reduced by application of granulosis virus to foliage of cabbage plants or to soil around the plants. Tests with another virus, the polyhedrosis virus of the cabbage looper, showed that the virus may remain active for long periods in soil and that it can be spread to the leaves of cruciferous plants by rain and probably by wind.

Thuricide, a commercially produced microbial insecticide that contains the bacterium *Bacillus thuringiensis* as the active ingredient, applied at 1 or 4 quarts/acre was less effective than carbaryl, a chemical insecticide, applied at 3 lb/acre for control of the European corn borer on sweet corn. Each material was applied four times in the plot test. Populations of the corn earworm were too low to indicate the effectiveness of these materials or of a polyhedrosis virus.

New Pests

The cereal leaf beetle, *Oulema melanopus* (L.), was found distributed over an area of about 70 sq miles in Essex County.

The alfalfa weevil, *Hypera postica* (Gyllenhal), was detected in Essex County for the first time in a limited area.

A leaf miner, *Liriomyza* sp., increased in numbers in 1967 as a pest of greenhouse tomatoes.

Selective Phytotoxicity of Dyrene to Varieties of Canada Thistle

Greenhouse and field experiments have indicated that the fungicide Dyrene is phytotoxic to the *mite*[4] variety of Canada thistle. The action of Dyrene was characterized by complete shoot kill in less than 24 hr and suppression of shoot regrowth for 3 months after treatment. No evidence of Dyrene phytotoxicity to plants of the *horridum*[5] variety was observed.

SOIL SUBSTATION, WOODSLEE, ONTARIO

Soil Fertility

Fertilizer for corn—A comparison was made of N, P, and K for corn on Brookston clay at Oil City in Lambton County and Woodslee in Essex County. Applications of 52.8 lb/acre P increased corn yield by 22.5 bu/acre at Oil City, but had little effect on corn yield at Woodslee. Nitrogen applied at 120 lb/acre increased corn yield 9.0 bu/acre at Oil City and 48.2 bu/acre at Woodslee. Soil test values indicated adequate or marginally inadequate soil P at Oil City, but crop response at this location was far greater than predicted from tests on Brookston clay at Woodslee.

In long-term rotation experiments, calcitic limestone at 2 tons/acre in 1953 had no effect on the corn crop until 1966. During the past 2 years the corn crops in the 2-, 3-, 4-, and 5-year rotations have shown consistent increases in yield averaging as high as 10.0 bu/acre due to lime application. These studies indicated that the pH and available Ca may be a limiting factor in corn production in some seasons.

Soil Physical Studies

Cropping systems—Rotation experiments were established in 1946 on Brookston clay to determine the effect of cropping systems on yield and on the soil.

[4] *Cirsium arvense* var. *arvense* (mite) Wimm. & Grab.
[5] *Cirsium arvense* var. *horridum* Wimm. & Grab.

Certain systems have been selected from the rotation experiments as reference plots for measuring the effect of cropping system on soil total pore space. In 1967, total pore space on continuous corn was approximately 5% less than following 1 and 2 years of alfalfa sod in the 3- and 4-year rotations.

A high-fertility experiment was established in 1952 to determine the effect of high fertilizer applications in maintaining yield of corn grown continuously, in comparison with a cropping system that included 2 years of alfalfa sod. The effect of these treatments on soil physical condition was determined by measurement of soil pore space. In 1967 the alfalfa sod treatment had greater total pore space than that of the check and two fertility treatments. All total pore space values, however, were over 50% in 1967, which is relatively high for this soil. Nitrogen supply was the predominant factor in corn yield.

Soil aeration—Recent work has shown that environmental factors, including air temperature and light intensity, increase the harmful effects of oxygen deficient conditions in soil flooding. Ethanol, measured as an indicator of anaerobic conditions in tomato plants, was increased by high air temperature and high light intensity under conditions of low oxygen diffusion rates. Excessive rainfall increased ethanol in field-grown plants following short periods of flooding in a pattern that agreed with growth-chamber results.

Cultural Practices

Cultivation for corn and soybeans—In contrast with previous years there was no significant difference in yield related to cultivation of corn or soybeans. Yields were variable as a result of flooding in early summer. There were yield trends, however, on the Oil City site in Lambton County favoring cultivation over other methods of weed control.

Physical measurements showed a considerably larger air pore space in the Brookston clay soil at Woodslee than on a similar soil at Oil City.

Direct seeding of processing tomatoes—Yield of marketable fruit was increased from 8.31 tons to 21.36 tons/acre by the use of a black plastic mulch on the variety Fireball seeded directly in the field. A band application of 150 lb/acre of 11-48-0 at the time of direct seeding resulted in yields of 12.09 tons without mulch and 22.94 tons with a black plastic mulch. Yields of transplants were 21.85 and 32.76 tons/acre without and with black plastic mulch.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Animert V101	Green Cross Products
CP50144	Monsanto Chemical
DuPont 1991	DuPont of Canada Limited
Dyrene	Chemagro Corporation
Fumazone	Dow Chemical Company
Galecron	Green Cross Products
Nemagon	Shell Canada Limited
Patoran	Ciba Company Limited
Planavin	Shell Canada Limited
Sutan	Stauffer Chemical Company
Temik	Union Carbide Canada
Vernam	Stauffer Chemical Company
Vorlex	Morton Chemical Company

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T. Rajhathy, Ing. Agr., M.Sc., D. Agr. Sci.	Head of Section Cereal cytogenetics
B. E. Murray (Miss), B.S.A., M.Sc., Ph.D.	Radiation genetics

Experimental Farm, Fort William, Ontario

W. B. Towill, B.S.A.	Superintendent

Experimental Farm, Kapuskasing, Ontario

J. E. Comeau, B.Sc. (Agr.), M.Sc.	Superintendent Soil fertility
J. M. Wauthy,[4] B.Sc. (Agr.)	Forage and cereal crops

Experimental Farm, Smithfield, Ontario

H. B. Heeney, B.Sc., M.Sc.	Superintendent Plant nutrition and irrigation
S. J. Leuty, B.S.A., M.S., Ph.D.	Fruit crop management
S. R. Miller, B.Sc., M.Sc., Ph.D.	Plant physiology and biochemistry
W. P. Mohr,[5] B.S.A., M.S.A.	Food processing

Departures

N. R. Bradner, B.S.A., M.S.A., Ph.D. Resigned July 1967	Legume breeding
P. Dermine, L.S.A., M.Sc. Resigned May 1967	Forage and cereal crops, Kapuskasing
E. B. Wagenaar, Ing. Agri., Ph.D. Resigned October 1967	Cereal cytogenetics

[3] A/Director, Research Station, Kentville, N.S. July 1967.
[4] Appointed September 1967.
[5] On educational leave, 1966–68.

VISITING SCIENTISTS

National Research Council postdoctorate fellows

R. S. Sadasivaiah, B.Sc. (Agr.), M.Sc., Ph.D., 1966–68 — Cereal cytogenetics

N. Thurling, B.Sc., Ph.D., 1966–67 — Cereal physiology

INTRODUCTION

This report summarizes the principal results of the work of the Research Station, Ottawa and the experimental farms at Fort William, Kapuskasing, and Smithfield. At the Station there has been steady progress in breeding, genetics, management, and associated scientific disciplines. Champ timothy and three new grain corn hybrids were licensed; new varieties of timothy, orchardgrass, reed canarygrass, and red fescue are at an advanced testing stage. The discovery of a source of cytoplasmic male sterility is another step towards the development of commercial hybrid alfalfa.

Important new sources of oat crown and stem rust resistance, and of high protein content were discovered in the *Avena* material collected in 1964 by the Canada-Wales expedition to the Mediterranean region; a new tetraploid species was described.

F_1 cucumber hybrids incorporating a new multiple disease resistant Ottawa breeding line were resistant to the new strain of cucumber mosaic virus. Progress was made in developing tomato breeding lines for mechanical harvesting; two new lines combine verticillium resistance with moderate crack resistance, uniform green fruit, and determinate plant habit. Linkage discovered between male sterility and a seedling marker gene in *Brassica oleracea* L. will greatly facilitate the production of hybrid seed of the cole crops.

The first three scab-resistant apple varieties were released for limited grower trial. Seven new, hardy, clonal, size-controlling apple rootstocks and four extremely hardy seed propagated standard rootstocks were released to research stations and selected growers for semicommercial trials across Canada.

At Fort William, research with field crops was continued in a program devoted to species evaluation, establishment, maintenance, harvesting, and preservation for the production of high-quality livestock feed. New projects were instituted at Kapuskasing, in cooperation with the Animal Research Institute, Ottawa, on the etiology of nutritional muscular dystrophy and on the interrelationship of winter housing and plane of nutrition in a beef cow-calf operation. The main emphasis at Smithfield has been on cultural management, breeding, physiology, and processing of apples, small fruits, and canning crops, with particular attention to problems associated with the short season and low winter temperatures typical of the area. Winter-hardy dwarfing and semidwarfing apple rootstocks are being tested. Cold resistant tomato varieties are being produced. A program is being established to evaluate the effects of macro- and micronutrient nutrition on low temperature resistance. Atomic absorption equipment has been installed for this study.

From the Station, Mr. Miller spent the winter of 1966–67 in Beirut, Lebanon, advising the government on setting up a wheat quality laboratory; Dr. Spangelo is acting director of the Research Station, Kentville, for 1 year beginning July 1967; Dr. Zillinsky is on leave of absence for 2 years at the International Centre for the Improvement of Maize and Wheat in Mexico. Mr. Mohr, Experimental Farm, Smithfield, continued studies for the Ph.D. degree at the University of Nottingham, England.

A. W. S. Hunter
Director

CEREAL CROPS

Winter Wheat

Breeding

Lodging—The 1967 growing season was ideal for lodging appraisal. Lines as lodging resistant as Talbot, some from 6 to 18 inches shorter, were selected and planted in adaptation trials at Ridgetown and Kemptville, Ont., and in the Ontario Winter Wheat Project Group trials.

Loose smut—Lodging-resistant lines derived from Kawvale × Genesee with more resistance than Kawvale to the loose smut races to which Genesee and Talbot are susceptible are being reinoculated for a second test.

Stem rust—Two lines with resistance to race 15B-1 L (Can.) and with better lodging and mildew resistance than Genesee were increased for regional testing and for large plot yield comparisons with Rideau and Richmond at Ottawa.

Winterhardiness (25)—Artificial freezing tests for winterhardiness were improved. Posthardening of winter wheat seedlings in plastic bags in the dark, after vernalization at 1.7 C, improved hardiness as indicated by survival and growth. A further increase in survival of certain varieties was obtained by extending the posthardening period to 2 weeks.

Hybrid Wheat

Cross-pollination—Seed set by natural pollination of emasculated varieties was 95% of normal so long as pollen supply was ample. Seed set on male steriles, derived from second and third backcrosses between male sterile spring wheat and winter wheat (recurrent parent), was about 15% of normal, owing mainly to their heading 7 days later than the winter wheat pollen parent.

Yield increase—Diallel crosses of two separate groups of seven and eight varieties, each including good and poor quality types, were tested for combining ability in the field. The best combination between good quality varieties yielded 36% more than the best variety of that type. A similar increase of 53% was obtained from the poor quality varieties. The effects of heterosis on several yield components were generally positive, but varied considerably. The greatest effect was obtained in the number of heads per plant, the best hybrid exceeding the parental average by 44%. For number of seeds per head the highest increase was 23% and for kernel weight 5.2%.

Quality—Crosses between varieties of the good and poor quality groups produced hybrids of quality similar to that of the parents (based on flour yield, water absorption, viscosity, and mixograph tests). Crosses between the groups produced intermediate types with one exception in which the quality of the good parent was recovered. That hybrid will be tested further.

Fertility restoration—Difficulty was encountered in transferring the *Triticum timopheevi* pollen restorer complex into winter wheat by recurrent backcrossing. The problem is a genetic one. The gene expression appears to be modified either by the genetic background of the recurrent parent, or the environment, or both. An examination of the original material carrying the pollen restorer complex showed that not all lines were fully homozygous for this character. An extensive reselection was carried out to eliminate heterozygous lines. The more recent crosses made with the fully homozygous material are expected to give better results.

Quality Evaluation

Quality evaluations were conducted on plant breeders' samples from the research stations at Ottawa, Harrow, and Lethbridge and the University of Alberta, on more advanced material from the Ontario Observation, Screening, Regional, and Cooperative Winter Wheat Tests, and on commercial samples collected to provide information on regional variation in winter-wheat quality. Of 1,075 samples, 307 required full-scale tests and 768 were evaluated by prediction test methods.

Oats

Interspecific investigations (17)—Further progress on gene-transfer techniques was achieved. Hexaploid bridging forms that possess much of the CD3820 (*Avena strigosa* Schreb.) genotype, developed originally for improving cross-compatibility with normal hexaploid oats, also improve the cross-compatibility of other desirable diploid species.

A new tetraploid species, *Avena magna* Murphy & Terrell, was found in material from the Canada-Wales (CW) collection of wild *Avena* species from the Mediterranean area. The plant, collected in northwestern Morocco, resembles *A. sterilis* L. morphologically. It has excellent resistance to crown rust, and its seed is very large and high in protein content. The species is cross-compatible with tetraploid, hexaploid, and some diploid species, but the resulting hybrids are sterile.

High protein content and new sources of resistance to crown and stem rust were found in the CW collections of *A. sterilis* from the Mediterranean area. Strain CW 417 produces an immune seedling reaction to stem rust race 6AFH; this resistance disappears after heading has occurred.

Breeding—Resistance to stem rust races 6A and 6AF and crown rust races 264 and 294 from *A. strigosa* variety CD3820 was incorporated into agronomically suitable hexaploid strains. New Ottawa strains continue to perform well in the Ontario Project Group and Cooperative tests. OA18-28 and selections from OA123 show adaptation over a wide range of conditions.

Dormoats—Dormoats carry seed dormancy from *A. fatua* L., and showed great potential as a means of minimizing the rust and septoria problem and of raising the yield barrier of oats, but low spring emergence of fall-sown seed is a weakness. Failure of seeds to overwinter results from germination in the fall, frost injury, and failure to break dormancy by spring. In 1967, the best survival was obtained by sowing seeds immediately after harvest at a depth of 3 to 4 inches. Delayed seeding reduced survival, but was successful when the metabolism of the seed was arrested in storage by either low temperature or lack of O_2 (vacuum or N_2 gas). Exposure of damp seeds to sunlight was also effective in preventing fall germination, whereas treatment with growth retardant chemicals (CCC[6] and B995[7]) was ineffective. Survival is also related to the *A. sativa* parent used in crosses with dormoat lines.

Preliminary data from crosses between wild oat strains and commercial varieties indicated that many genes are involved in dormancy and that the type of dormancy influenced by sunlight is linked to the commercially undesirable wild oat characters. The type of dormancy conditioned by low O_2 tension may also be linked with wild oat characters because it is common to observe, in the regular dormoat material in spring, a disproportionate number of wild types.

Twin oat seedlings—Twin seedlings occurred with an unusually high frequency (0.1%) in several dormoat lines derived from a cross *A. sativa* var. Clintland × *A. fatua*. The twins usually were unequal in size and differed in chromosome number. The large seedling was invariably fertile; those counted had 42 chromosomes. The small seedling was either fertile ($2n = 42$), or was highly sterile and had either 56 or 63 chromosomes. No seeds were obtained from 56 chromosome plants, but a low frequency of 56 chromosome plants was obtained from 63 chromosome plants. Micronuclei are common in meiotic cells of both 56 and 63 chromosome plants.

Barley

Breeding—Two barley selections, OB66-23 and OB66-13, from the cross Nord × Br. M57-754, have performed extremely well in Ontario yield tests. Both are resistant to powdery mildew and loose smut. OB66-23 was among the highest yielding varieties in the 1966 Eastern Cooperative Barley Test, conducted at 13 locations in

[6] Obtained from Eastman Organic Chemicals Distillation Products Industries.
[7] Obtained from U.S. Rubber, Naugatuck Chemicals Division.

Eastern Canada. OB86-9 and OB95-9, from the cross ((3643B × Fort) × (Anoidium × Fort²)) × York have better lodging resistance than York, and have yielded well in the Ontario tests. They are resistant to powdery mildew but susceptible to loose smut.

Marked progress has been made in selecting for hardiness in winter barley. Survival data obtained at Ottawa in 1967, a year of good differential killing, showed the superiority of most of the winter-type selections over Dover, the recommended variety in Ontario.

Interspecific hybridization—A large population of *vulgare* types, obtained from hybrids of *H. vulgare* L. × *H. murium* L., has yielded agronomically promising genetic stocks. Fully fertile spring and winter tetraploids were obtained from interspecific hybrid derivatives involving *H. vulgare, H. murinum, H. bulbosum* L., and *H. spontaneum* C. Koch, following chromosome doubling. Crosses between *H. bulbosum* 2x and *H. vulgare* 2x resulted in 19 haploid plants.

Field Peas

In the progeny of a cross between Weitor 702 (good cooking quality) and Kapuskasing 388-4 (poor cooking quality), good cooking quality appears to be controlled by two recessive genes and there is some indication of a gene–environment interaction. The data suggest that selection for good cooking quality may be most efficiently begun at the F_4 generation. Cooking quality is weakly related to the Ca to phytin-P ratio and to the phytin-P content of peas.

Physiology

Selection of oats for protein content by half-kernel method—Interest is growing in the potential use of oats as a rich source of protein. A few lines of one hexaploid interspecific oat population were found to possess protein contents in the seeds ranging from 14.5% to 28.5% (macro-Kjeldahl method). In developing a screening technique to use in breeding for protein content it was found that the protein content of the endosperm half of seeds from 29 oat varieties was correlated highly with that of both the embryo half (r=0.94***) and the whole kernel (r=0.96***). The correlation between the protein content of the endosperm halves of 200 seeds from each of the interspecific oat populations OA123 and 958 (Coleman Nitrogen Analyzer micro method) and seeds from plants grown under field conditions from the embryo halves of these kernels (macro-Kjeldahl method) was r=0.52** and r=0.26**. In practice, if the top 10% of each population had been selected (micro data) for high protein content, 80% of these selections would have been above average in protein content the next year when enough seed was available for macro determinations.

Pathology

Septoria disease of oats—Lack of adequate screening techniques seriously hinders breeding oats for resistance to the fungus *Septoria avenae* Frank f. sp. *avenae*. Considerable differences among varieties, lines, and species are shown by classifying resistance according to lesion size after macrospore inoculation of seedlings in the greenhouse or by inoculating detached leaves in test tubes and incubating them for 4 days in a growth room. Further work is required to relate these results to field resistance. A reasonable level of resistance was found in *A. strigosa* by the detached leaf method, but other species collected by the Canada–Wales expedition to the Mediterranean region showed little resistance.

Chemical treatment of oat seed—To test the possible detrimental effect on plant

growth of treating healthy cereal seed with chemicals, especially mercuries, sound seeds of five common oat varieties were treated with the mercurial fungicides Ceresan M,[8] Liquisan 10L,[9] and Pandrinox Liquid Combination,[10] and the nonmercurial fungicides HRS 1591A[11] and Chemagro 4497.[12] Over a 3-year period there was a consistent slight increase in percentage of emergence and kernel weight from treated seeds. Yield increases were not consistent and the differences were not significant. The type of fungicide appeared to have little influence on the results obtained. In 2 out of 3 years, yield increases were obtained by treatment with a methylcellulose sticker only.

Control of oat crown rust—Preliminary experiments indicated that the fungicide Daconil 2787[13] may be useful for the control of crown rust of oats, caused by *Puccinia coronata* Cda. f. sp. *avenae* Erikss. & Henn. Four applications at weekly intervals, or after a period of rain if this was sooner, reduced a heavy natural infection to a trace and resulted in an average yield increase of approximately 25%. Kernel weights were not changed by the treatment.

Effect of storage gases on oat seed microflora—During an experiment on the dormancy of oat seeds, certain gases were observed to influence the kind of microflora present on the seed. Pure oxygen eliminated many of the fungi but not the bacteria. Pure nitrogen favored a build-up of *Penicillium* spp., all seed becoming infested and often in pure culture. Untreated seeds were infested primarily with *Alternaria* and *Fusarium* spp. and with a few colonies of *Penicillium* spp.

FORAGE CROPS

Grass Breeding

Timothy

The four-clone synthetic timothy variety Champ, *Phleum pratense* L., was licensed in 1967. It is a high-aftermath type, 5 to 7 days earlier in maturity than Climax. In a 33-station-year test it slightly exceeded Climax in total dry matter and produced 24% more aftermath. Champ is being multiplied under the Canadian Forage Seed Project, and Foundation seed for Certified seed production is available.

In a study of breeding methods, two of the best clones of Champ, #2 and #9, were selfed, then put through two cycles of close breeding under isolation. The resulting progeny were compared at nine locations with the original four-clone synthetic. Preliminary results showed no loss of vigor from selfing. In most tests, one or the other clone outyielded Champ. Clone #9 yielded 30% more seed than Champ at Ottawa.

The variety Bounty, recommended as a late-maturing timothy for New Brunswick, was licensed in 1966 and multiplied under the Canadian Forage Seed Project. Approximately 8,000 lb of Certified seed was available in the fall of 1967.

Ottawa 1, a wide-leaved, vigorous, attractive timothy rated equal to Climax in country-wide yield trials, is being increased by the Station.

Orchardgrass

Data obtained in 1967 confirmed previous indications that the orchardgrass, *Dactylis glomerata* L., variety Strain K, based on an introduction from Leningrad, is well adapted to growing under cool, wet spring conditions. It is late, leafy, extremely hardy, and starts spring growth earlier than all other late strains. Excellent results were obtained at Fort William, Ont., Laval University, Que., and in Nova Scotia.

Another strain called Bumper is late, leafy, and more desirable in mixtures with alfalfa. It does not start as early in the

[8] Obtained from E. I. DuPont de Nemours Co. Inc.
[9] Obtained from Green Cross Products.
[10] Obtained from Morton Chemical Co.
[11] Obtained from Hooker Chemical Co.
[12] Obtained from Chemagro Corp.
[13] Obtained from Diamond Alkali Co.

spring, but produces more aftermath in July and August than Strain K. More information is needed on winterhardiness.

Bromegrass

A study was initiated to improve seed production of Redpatch bromegrass, *Bromus inermis* Leyss., which, in common with other southern-type varieties, is low in seed yield. Syn 1 progeny of a synthetic composed of the nine highest seed-producing clones of the 21 clones of Redpatch gave single-plant seed yields ranging from 4 to 156 g. Polycross progeny from the 20 highest-yielding plants will be used for a second cycle of selection for seed yield. Nurseries of the same genetic constitution (second cycle only) are being established in Western Canada where most of the bromegrass seed is produced.

Reed Canarygrass

Grove, a new late maturing variety of reed canarygrass, *Phalaris arundinacea* L., will be recommended for licensing. It is 7 to 10 days later than Common and, although not as productive, it is extremely leafy, responds well under high fertility and moisture conditions, and is expected to be useful in managed green-chop programs.

Red Fescue

Durlawn, a new variety of red fescue, *Festuca rubra* L., that combines the attributes of good turf-forming ability with good seed production is being introduced for increase in 1968. The 20 clones comprising this synthetic variety have been thoroughly tested over a 6-year period.

Alfalfa Breeding

Cytoplasmic male sterility (2)—The search for cytoplasmic male sterility in alfalfa, *Medicago sativa* L., was continued, using male sterility in the F_1 from crosses between highly male fertile and completely male sterile plants as the selection criterion. During the winter of 1966–67, 5,600 hand pollinations were made on 800 plants. Over 200 of the resulting seedlings have been screened for male sterility; three crosses gave small progenies that were almost completely male sterile. The likelihood that they were the result of genetic segregation is only 1 in 100, but larger populations will be grown to prove the results.

Bacterial wilt resistance—In the program to incorporate bacterial wilt resistance into adapted varieties begun in 1958, six Du Puits synthetics involving different numbers of clones were established under isolation. A 25-clone synthetic, OD25, has been moved to the Syn 3 generation and was included in a uniform yield test at 13 locations. Five other smaller synthetics established for high seed set, high protein content, and specific combining ability are at the S_1 stage.

Six Rhizoma synthetics have been isolated for seed increase, two at the Syn 2 and four at the Syn 1 stage. None has been released for comparative testing.

Symbiosis between alfalfa and rhizobium in acid soils—A defect of alfalfa is its poor performance on acid soils. Seedling growth of Vernal alfalfa and strain AT4, selected from Vernal for its tolerance to acid soils, was compared in acid media inoculated separately with three Australian strains of *Rhizobium* selected for adaptation to acid conditions. Growth of the selected alfalfa strain AT4 exceeded that of Vernal with all three *Rhizobium* strains.

Corn Breeding

Three new hybrids were released for commercial production, one each to Pride Hybrid Co. of Canada, United Seed Services, and United Cooperatives of Ontario. These hybrids are expected to find their greatest use in southern Quebec and central and eastern Ontario.

A backcrossing program was started to incorporate the genes opaque-2 and floury-2 in a number of inbred lines. Their

effect is to increase lysine and tryptophan and thus improve protein quality.

Most of the 118 European introductions received in 1967 were top crossed with Minnesota 13 as the first step in testing their combining ability.

Testing of tillered hybrids for silage at research stations across Canada indicated a consistent yield advantage over nontillering types, except where available heat units approached 3,000. Here the longer season favored the later maturing nontillered hybrids.

Soybean Breeding

Approximately 600 plants were selected, on agronomic characters, in segregating material from eight crosses involving Canadian varieties of group 0 and 00 maturity and still earlier Swedish lines. These will be selected further for oil content. Ten new crosses were made between Canadian varieties and Swedish lines. These Swedish genetic stocks are very early maturing and have a good oil content, but the plants are short and the seed tends to shatter when ripe. In spite of these defects they are the best prospect for making significant advances in shortening the growing period.

In breeding for high protein content, some 50 selections were made in segregating material from six crosses involving Canadian varieties and high-protein strains from the U.S. Regional Soybean Laboratory, Urbana, Ill. Further selection will be made on protein content. Currently available early maturing, high-protein lines have rather poor agronomic qualities. Experience suggests that at least one backcross to commercial varieties will be needed to obtain a desirable plant type.

Physiology

Competition in grass–alfalfa mixtures— The proportion of grass in alfalfa–timothy and alfalfa–bromegrass mixtures is influenced by the method of seeding. The contribution of grass to the yield increased from broadcast, to 7-inch row seedings (mixed in the row), to alternate 7-inch rows of legume and grass.

The timothy offered very little competition to the alfalfa; it reduced alfalfa yields by less than 5% in all treatments. Bromegrass, on the other hand, reduced the yield of alfalfa by 15, 35, and 50% in broadcast, mixed-row, and alternate-row seedings respectively. The addition of grass to the broadcast seedings did not result in total yields different from those obtained from a pure stand of alfalfa. In the row seedings, the grasses more than compensated for the reduction in alfalfa yield. Timothy increased the total yield by 10% over pure alfalfa in both instances, whereas the addition of bromegrass increased the total yield by 15 and 35% in the mixed-row and alternate-row seedings.

Intraspecific competition, determined by comparing yields from 14-inch rows of pure alfalfa with half-plot yields from 7-inch rows, reduced yield by the same magnitude as interspecific competition from bromegrass in alternate rows.

Effect of leaf width on timothy yield— A differential response to density of stand was found in narrow- and wide-leaved timothy selections from each of the two experimental strains Labelle and Line 2. When grown in a growth room under two density and two fertility regimes, the wide-leaved timothy was higher yielding under low density. At high density, the narrow-leaved plants were equal to or higher yielding than the wide-leaved, which shows that narrow-leaved selections offer the greater potential for increases in yield in dense stands. The narrow-leaved plants also tended to give the greater yield increase with increasing fertility, but the response was not as pronounced as with density.

Pathology

Host–Pathogen Relations

Nutrition in relation to development of fusarium wilts and root rots of alfalfa—Host nutrition was shown to be an important factor in the development of fusarium wilts and root rots of alfalfa seedlings. Nitrogen and K had the greatest effects on ultimate disease severity. Osmotic pressure of the nutrient solution appeared to influence plant growth and disease development. High osmotic pressure, in an otherwise balanced nutrient solution, retarded growth and reduced disease severity.

Enzyme production of Fusarium *spp. from alfalfa*—Culture filtrates of *Fusarium* spp. grown on media containing pectin were able to reduce markedly the viscosity of sodium polypectate or, more slowly, that of pectin. Tests for the liberation of reducing groups as a result of galacturonic acid end-group hydrolysis were repeatedly negative even after prolonged incubation. *Fusarium* spp. from alfalfa appeared to have a pectic depolymerase rather than the classical fungal polygalacturonase.

Sugar content of healthy and Fusarium*-infected alfalfa plants*—Fructose, glucose, sucrose, raffinose, and galactose, separated by paper chromatographic procedures from healthy and infected plants of the susceptible variety Rhizoma and the tolerant variety Vernal, were measured quantitatively using a Spectronic 20. *Fusarium*-infected Rhizoma had a higher free-sugar content than noninfected; little or no measurable differences were found in Vernal.

Phenolic content of alfalfa—In a preliminary study of the nature and kind of phenolic compounds in alfalfa in relation to disease resistance, the following were detected chromatographically by comparison with published R_f values and color charts: coumestrol, salicylic acid, trifoliol, sativol, and tricin.

Introductions

The most interesting new introductions observed in 1967 were: a giant alfalfa, *M. sativa,* selected from a Swedish introduction; an early strain of orchardgrass, *D. glomerata,* from Riga, Latvia, that survived 100% the severe winter of 1965–66; a vigorous, high-yielding strain of timothy, *P. pratense,* from England that is 10 to 14 days later than Climax and has excellent seeding habits, but is low in aftermath production; *Trifolium caucasicum* Jausch. from USSR grows 8 to 9 inches tall and is a very hardy perennial white-flowered clover; *T. canescens* Willd., Caucasian clover, is much like the above species, but is more leafy and less hardy.

Forage species for dryland areas—A test was established in 1966 on a gravelly, sandy loam hilltop to investigate the adaptability of a selected group of grass and legume species to poor, light, droughty soils. Some grass and legume species produced very respectable dry matter yields in 1967, a year of adequate moisture, but conclusive comparisons must await a year when moisture stress conditions prevail.

Seed setting of Italian ryegrass—Italian ryegrass, *Lolium multiflorum* Lam., acts as an annual in this area and does not produce heads unless the seed is vernalized. This may be accomplished by seeding in late fall just before freeze-up or in early April when the seed is subjected to frequent frosts. Of 12 varieties planted in mid-May, only Westerwolth's varieties produced seed the first year. Vernalization in a refrigerator at 32 and 34 F for 4 weeks did not stimulate general heading.

Foreign forage varieties—Unlicensed foreign forage varieties may be increased in Canada for export to the country of origin. A program has been initiated as a service to seed growers, to test foreign varieties for their adaptation to seed production in Canada. The Station is conducting these tests in Eastern Canada. The first plantings were made in August 1967.

HORTICULTURAL CROPS

Fruits

Strawberries

Genetics (27)—From a comparison of full, half, and quarter diallels involving eight parents it was concluded that very good estimates of genetic components could be obtained from quarter diallels at a considerably reduced cost compared to full diallels.

Estimation of the importance of epistasis was continued using four quarter-diallel experiments harvested in 1967. The parents involved represented high-yielding North American cultivars.

Evaluation of various methods of using discriminant-function selection indices showed that the best results were obtained when only the minimum number of characters known to be vital to a particular selection objective were used. The use of the main character and only characters having stable correlations with it produced a poor index. The worst index was obtained when all available characters were included.

Testing of advanced selections here and at the Experimental Farm, Smithfield, has shown the importance of selecting simultaneously for all the important characters desired. Quality is rarely found in strawberries selected only for yield.

Disease resistance—Varieties bred here transmit a higher degree of resistance to powdery mildew, *Sphaerotheca macularis* (Wallr. ex Fr.) Magn. (*S. humuli* (DC.) Burr.), to their progenies than do most other North American varieties. In genetic studies the high-yielding strawberry plants appeared to be more susceptible to leaf scorch, *Diplocarpon earliana* (Ell. & Ev.) Wolf, than low-yielding plants, suggesting that it may be difficult to combine high yield and leaf scorch resistance in one plant.

Raspberries

Morphological components of yield—The merit of inbreeding by selfing is being assessed by comparing the proportion of desirable selections in test crosses to selected individuals within successive generations of inbreds of Trent, Muskoka, and Tweed, relative to test crosses to the noninbred varieties. Analyses of the non-selected third-generation inbreds grown as spaced plants showed that yield still exhibited considerable variation within lines. In contrast, plant height and time of flowering were approaching uniformity within lines. High correlations with yield were found for number of canes, number of branches, number of flowering laterals, and earliness of flowering. The last two of these correlations were also among the highest for virus-free cultivars and clonal selections grown in the conventional linear system.

The genetic information gained in this study, together with information derived from shake-and-catch harvesting experiments, will be used to plan the breeding for mechanical harvesting. Interaction between yield and method of harvesting indicates that selections chosen for hand-picking may not be suitable for mechanical harvesting.

Apples

Genetics—Data have been collected, but the analyses have not been completed on genetic components in hybrid apple seedling rootstocks and on genetic variance in progenies segregating for scab resistance. In the first, apple rootstock progenies were subjected to artificial stresses using a portable low-temperature chamber during two winters. Analysis of the winter survival data from the half diallel involved will disclose information on the relative importance of the genetic components. In the study of genetic variance, the relative importance of general and specific combining ability components of winter survival is being determined in progenies segregating for resistance to scab, *Venturia inaequalis* (Cke.) Wint. Similar information is being obtained from a quarter diallel for crosses between size-controlling rootstocks.

Breeding for scab resistance—The first three scab-resistant selections to be good

enough for limited grower testing have been released. These are:

0-521—as hardy as McIntosh, good appearance and quality, resistant to mildew, *Podosphaera leucotricha* (Ell. & Ev.) Salm.; this selection should be marketed by January 1.

0-522—as hardy as McIntosh, good appearance and quality, resistant to cedar-apple rust, *Gymnosporangium juniperi-virginianae* Schw.; this selection should be marketed by December 1.

0-5210—good appearance and quality; this selection should be marketed by November 1.

Two advanced scab-resistant selections, 0-520 and 0-523, being tested at the John Innes Institute in England, proved to be susceptible to a new race of scab that attacked all selections derived from *Malus atrosanguinea* 804. Selections derived from *M. floribunda* 821 were not affected.

Chemical analyses of leaves and fruit (10)—Analyses carried out in cooperawith the Food Research Institute on leaf and fruit samples from adult trees showed that the amount of certain chemical constituents of leaves can be used to predict fruit quality. Extended to selection of 1-year-old seedlings, this would result in a large reduction in the time and cost of breeding new varieties.

Winterhardiness of Quinte—Tests on winter survival using artificial cold stresses indicated that Quinte (named in 1964 and favorably received by growers in Ontario and Quebec) can withstand lower winter temperatures than McIntosh.

Size-controlling clonal rootstocks—Seven new rootstocks tested for hardiness, stoolbed propagation, mistbed propagation, virus tolerance, collar rot resistance, bud compatibility, and plant type and ranging in predicted size-control from approximately equal to Malling IX to approximately equal to Malling II, are now available for testing across Canada. They are: 0-4, 0-5, 0-7, 0-8, 0-11, 0-12, and 0-13. In tests all seven were tolerant of a complex of rubbery wood, stem pitting, chlorotic leaf spot, and flute fruit viruses. In cooperation with the Research Station, Summerland, they were tested for resistance to collar rot, *Phytophthora cactorum* (Leb. & Cohn) Schroet. Most of these rootstocks showed some measure of resistance, but only the 0-3 gave an immune reaction.

Seed-propagated rootstocks—The hardiest apple seedlings tested, exact seed source unknown, but arbitrarily called *Malus baccata* (China), survived an artificially applied air-temperature stress of −64 F. After 52½ hr of this stress the soil temperature at 4 inches had dropped to −11 F. Selections from this material, along with other hardy parents, will be used in future breeding.

The production of uniform, size-controlling rootstock progenies requires the testing of a large number of crosses because most of the progenies involving size-controlling parents have an excessively high degree of variability for plant type. Four new extremely hardy seed-propagated standard rootstocks having acceptable plant types are ready for nursery evaluation. They are identified as Ottawa Hybrids 1, 2, 3, and 4. These showed some resistance to collar rot in tests at Summerland, and they are tolerant of the rubbery wood, stem pitting, chlorotic leaf spot, and flute fruit virus complex.

Pears

New variety, 0-291—The parentage is Winter Nelis × Bartlett. The fruit is medium sized, heavily russeted, of fine juicy texture with no large stone cells, and of very good quality. It keeps well in cold storage until nearly Christmas. Although the tree has shown slight winter injury here, it has borne a heavy crop each year.

Pathology

The apple scab fungus in eastern Ontario—An isolate of *Venturia inaequalis* (Cke.) Wint., the causal organism of apple scab, from apple leaves in the Ottawa area caused infection on seedlings TsR-18T9 and TsR18T13. Because these seedlings are resistant to races 1 and 3 of the fungus, it is apparent that race 4 occurs

naturally in this area. An isolate of the fungus from a scab-resistant selection at Smithfield, Ont., gave similar results. The original description of race 4 suggested that it was a mutation from race 2 and, if this is the case, that race also occurs in eastern Ontario.

Incidence of strawberry virus diseases in certified stock—Strawberry plants from certified stock of the variety Redcoat that showed below-normal vigor were collected from 20 locations in Ontario and Quebec. Of 400 plants examined, 27 were infected with veinbanding, latent C, mottle, or a combination of latent C and veinbanding viruses. These infected plants represented about 0.7% of the total clones in the plantations.

Inactivation of latent A virus in strawberries—When strawberry plants were subjected to 43 C for 8 to 14 days, the latent A virus was inactivated. All the present nuclear stocks available for certification programs, except the varieties Earlidawn and Senator Dunlap, have been freed of this virus.

Raspberry virus diseases—The heat-labile components of raspberry mosaic virus were inactivated in the purple raspberry variety Columbian by treatment for 4 weeks at 40.5 C. This is the first known source of mosaic-free plants of this variety.

Vegetables

Genetics and Breeding

Cucumber breeding for multiple disease resistance—The new breeding line, Ottawa 67, combines resistance to scab, *Cladosporium cucumerinum* Ell. & Arth., derived from the cultivar Highmoor; cucumber mosaic virus, *Marmor cucumeris* var. *vulgare* Holmes, from Niagara and Tablegreen; and bacterial wilt, *Erwinia tracheiphila* (E.F. Sm.) Holland from P.I. 200818 of the USDA. Test F_1 hybrids from crosses between Ottawa 67 and Ottawa gynoecious lines derived from P.I. 220860 showed no virus symptoms in 1967, whereas all but 3 of 45 cultivars were slightly, moderately, or severely infected.

Segregation in field-grown F_2 plants of Marketer × Tokyo Long Green indicated multigenic resistance to cucumber mosaic virus; this supports earlier observations from artificial inoculations in the greenhouse.

Inheritance in cucumber—Segregation in gynoecious F_2 and backcross progenies showed that cluster flowering, two to several pistillate flowers at one node, is recessive to single flower and is monogenic. The gene symbol *cl* has been assigned. Differences between the reciprocal combinations, cream cotyledon (*cc*) × normal and *cc* × yellow cotyledon (*yc*) indicated that inheritance of cream cotyledon is purely maternal and probably due to plastid differences. Linkage between glabrous and perfect flower was observed in a segregating population, where 35 of 42 glabrous (*gl*) plants were perfect flowered (*Acr g*) and all 68 hairy (*Gl*) segregates were *acr G*.

Resistance to root rot in peas—Evidence was found for multigenic resistance to *Fusarium solani* (Mart.) App. & Wr. f. *pisi* (F. R. Jones) Synd. & Hansen in artificially inoculated F_2 and F_3 progenies. To pool genes for resistance, eight Ottawa selections with diverse genetic constitutions were intercrossed. Michauxii × P.I. 180868 showed superior tolerance in a comparison of 20 F_1 progenies. Later, in the F_2 of that cross, there were three times as many survivors as in the most susceptible of nine F_2 populations tested.

Inheritance of decumbent plant in eggplant—Segregation in reciprocal F_2 eggplant, *Solanum melogena* L., progenies of the cross upright × decumbent, and in the corresponding two backcrosses, showed that decumbent is monogenic and recessive. The gene symbol *dec* has been assigned to this trait, which was found in a population of P.I. 105446 acquired by the USDA from Turkey.

Genetics of Brassica oleracea *L.* (24)—Linkage of 5.3 ± 1.5% between genes for male sterility (*ms-1*) of green sprouting broccoli and colorless hypocotyl (*c-1*) of curly kale should provide an economical means to produce F_1 hybrid seed. The linkage will permit roguing of most male

fertile plants from *ms ms* × *Ms ms* crosses 1 day after germination. This linkage was discovered in a small F_2 in 1966 and confirmed by four F_2 progenies raised in 1967. The combined results from selfing four *C-1 ms-1/c-1 Ms-1* plants were 2,285 *C-1 Ms-1;* 1,219 *C-1 ms-1;* 905 *c-1 Ms-1;* and three *c-1 ms-1* plants. A few plants showed a different type of reduced anther than that caused by *ms-1*. This suggested meiotic irregularity. Cytological analysis of the three *c-1 c-1 ms-1 ms-1* recombinants showed that each was heterozygous for a major translocation. It remains to be determined whether or not the *c-1 ms-1* linkage is independent of the translocation. Perplexities in the literature on the inheritance of anthocyanin were solved by showing that what previous workers took for separate genes are, in fact, alleles at one locus.

Tomato breeding lines resistant to verticillium wilt—Two promising new advanced breeding lines, Ottawa 79 and Ottawa 80, combine resistance to *Verticillium albo-atrum* Reinke & Berth. with moderate crack resistance, uniform green (*u*) fruit, and determinate plant habit (*sp*). They are medium early and yield heavily in verticillium-infested soil here.

Inheritance of skin toughness in tomatoes—Skin toughness was transmitted to the F_1 fruit in crosses of two extremely tough-skinned breeding lines resistant to radial cracking, with two tender-skinned, crack-susceptible lines. Puncture tests of the F_1 fruits showed that their skin strength was intermediate between the crack-resistant and crack-susceptible parents.

Tomato skin strength and stage of maturity—Skin puncture tests with three varieties of known reaction showed that puncture resistance was greatest in mature-green fruits, intermediate at the breaker or first-color stage, and least in fully red fruits. Wide variation within varieties at the mature-green and breaker stages indicated the difficulty in picking fruits of uniform maturity at these stages. This variability was greater in two varieties with uniform green (*u*) skin color than in the third with normal dark green (u^+) shoulders. The least variation in puncture resistance was found at the fully ripe stage in each of the varieties, which shows that sampling was more accurate when done at this stage.

Pathology

Root rot of pea in Ontario—F. solani f. *pisi* was isolated from diseased peas in 29 out of 31 fields sampled in Ontario. Extreme differences in pathogenicity were observed when these isolates were used to inoculate peas in the greenhouse. In almost all cases, isolates showing the highest degree of pathogenicity under controlled conditions were obtained from fields that showed a high incidence of root rot.

Potatoes

Breeding and evaluation for Ontario—In 1967, 921 selected second clonal generation seedlings from the Research Station, Fredericton, N.B., and 6,000 new seedlings, representing 60 crosses, from the University of Guelph were screened under the potato breeding project carried on cooperatively with the University of Guelph. Of the seedlings from Fredericton, 164 were retained for further evaluation in Ontario; 55 of these were also selected for retrial in New Brunswick, an unusually high percentage considering the differences in environment. About 3% of the Guelph seedlings were retained for further testing.

The Ontario Regional Potato Committee recommended the licensing of two new potato varieties in Canada after extensive testing in Ontario regional trials:

Cariboo—A late-maturing, round blight- and scab-resistant variety with pink eyes and red skin splotches at the seed end; suitable for tablestock and for chip processing; originated at the Research Station, Fredericton, N.B.

La Rouge—a medium-late, round to oblong, red-skinned, scab-resistant,

high-yielding tablestock variety; originated in Louisiana, USA.

Advanced clones with good potential for future release as commercial varieties are:

F5570—a Fredericton-bred, high-yielding, maincrop tablestock variety.

Wash. 48-1—a high-yielding, maincrop introduction from Washington State with high resistance to verticillium wilt, common scab, and leaf roll virus.

Chieftain—an early sizing, red-skinned, scab-resistant, and high-yielding tablestock variety from Iowa.

Roses

Breeding—The first year's results from a countrywide test of selection F06, an open-pollinated seedling of the *Rosa rugosa* Thumb. hybrid 'Schneezwerg', are encouraging. A second selection of similar parentage is being propagated for extended testing.

Most of the seedlings from crosses of Schneezwerg with the *rugosa* hybrid Frau Dagmar Hartopp have attractive flowers and are hardy, resistant to mildew, and flower throughout the summer. A few were selected for further evaluation.

Hybridization of F06 with *Rosa chinensis* Jacq. cultivars is desirable, but difficult because of the low fertility of F06. To improve fertility, F06 was crossed with the *rugosa* hybrid Will Alderman. Most of the seedlings have attractive flowers, are hardy, and flower throughout the summer, but are very susceptible to mildew. Two fertile, mildew-resistant seedlings with outstanding appearance were retained.

Seed germination—Germination of rose seeds is sporadic, even after stratification for 150 days at 3 C. Soaking in concentrated sulfuric acid or abrasion of the seed coat were effective only when followed by stratification. Seed dormancy and response to treatment vary with cultivar, pollen parent, and time of the year at which the seed matures. After-ripening for 60 days at 20 C followed by 90 days at 3 C gave satisfactory results with seeds from different cross combinations of hardy and tender cultivars. Seeds from crosses between hardy cultivars germinated more readily when after-ripened for 30 days at 20 C followed by 150 days at 3 C.

AGRONOMY

Cereal Crops

Seeding and fertilizer rates for oats—Differences in seeding rates (6, 9, 12, and 15 pecks/acre) did not produce yield differences for Stormont or Garry oats grown at five stations for 3 years. Each increase in fertilizer rate from 200 to 400 to 600 lb/acre of 8-16-16 gave yield increases of less than 100 lb/acre. Garry showed slightly better response to fertilizer than Stormont. Differential lodging did not occur in any of these tests. Nitrogen applied to cereal crops in the seedling stage, NH_4NO_3 and urea at 10, 20, 30, and 40 lb of N/acre generally failed to increase yields of Stormont and Russell oats and Herta barley at three locations in 1966 and 1967. Added N had no effect on the yield of oat grain or straw. Grain yield of barley showed a progressive increase with increased rates of N in 1 year at one location. Straw yield was not improved by N application.

Grasses

Reed canarygrass renovation—Nitrogen fertilizer at 80 lb of N/acre more than doubled the yield of a 4-year-old stand of reed canarygrass, *Phalaris arundinacea* L. (2-year average dry-matter yields were 1,953 and 4,774 lb/acre), or a total increase over the 2 years of nearly 3 tons of dry matter for an outlay of about $16 for fertilizer. Rototilling to break up root compaction reduced yield the first year to 439 lb/acre, but produced 4,867 lb/acre the following year.

Sorghum – Sudan Grass Hybrids

For sorghum – Sudan grass hybrids here, a two-cut schedule provided the best combination of high yield and quality without increasing labor unduly. Three-year average seasonal dry-matter yields for one-cut (September), two-cut (July and September), and three-cut (July, August, and September) schedules were 9,708, 8,584, and 4,763 lb/acre respectively. Total crude protein averaged 630, 1,326, and 912 lb/acre respectively.

Seeding on June 5 with 7-inch row spacing gave significantly higher dry-matter yields than seeding on June 22 with 14- and 28-inch spacings. Seeding rates ranging from 5 to 40 lb/acre showed a slight but not significant yield difference in favor of the lighter rates at each row spacing.

Corn for Silage and Grain

The unusually favorable 1967 season resulted in much above average yields of nearly 7 tons of dry matter/acre of silage and 139 bu/acre of shelled grain. In comparisons of 15 hybrids at 19,600, 22,400, 26,000, and 31,200 plants/acre in rows 20 and 40 inches apart, the highest average silage yields were produced by the highest populations at both row widths, although some specific hybrids produced more at 26,000 plants/acre. Grain production was best at the highest population in 20-inch rows only. In 40-inch rows the 22,400 and 26,000 populations were higher yielding. Usually 18,000 to 20,000 plants/acre is the most reliable rate for good grain yields combined with early maturity. Somewhat higher populations are acceptable for silage.

Neither reduced plant populations (13,000, 15,500, and 19,000 plants/acre) nor N side-dressing (60 and 120 lb N/acre) overcame the disadvantage of late-planted (June 2) silage corn. For 12 hybrids, 15,500 plants/acre averaged the highest silage yields. Added N did not pay for itself in increased yields. When grown for grain under the same conditions, added N depressed yields. There was little difference between the 15,500 and 19,000 plants/acre populations; the 13,000 population produced nearly 14% less grain. Neither plant population nor N rate appeared to affect maturity.

CYTOGENETICS

Avena

Cytogenetics—Recent chromosome studies suggested that *Avena ventricosa* Bal. is the potential donor of the C genome of hexaploid *Avena*. Two samples of the ssp. *bruhnsiana* were collected for us by Russian botanists in the Baku area, USSR. The karyotype of one sample is identical with that of ssp. *ventricosa* (Canada-Wales collection, Oran, Algeria); the other has a pair of submedian chromosomes. Hybrids involving the two *bruhnsiana* and the *ventricosa* samples have been produced for further studies of pairing affinities.

A new tetraploid species (17)—The karyotype of the new tetraploid species *A. magna* Murphy & Terrell, collected by the Canada–Wales expedition in Morocco, was distinctly different from that of the other tetraploid species. Hybrids were produced with the tetraploids *A. barbata* Pott and *A. abyssinica* Hochst., and with hexaploids and diploids for studies of chromosome homologies.

The A and B genomes—Pairing affinities of the A and B genome chromosomes in relation to the cytogenetic architecture of the tetraploid species were studied in triploid (A$_s$AB) and tetraploid (A$_s$A$_s$AB) hybrids. A precise karyotype of the tetraploid species and the triploid hybrid was constructed. The chromosomes of the A$_s$, A, and B genomes were compared and the following conclusions were reached: the A$_s$ and A karyotypes are identical; the karyotypes of A and B are similar but not identical; the A$_s$ and A genomes are highly homologous; the A and B genomes are homoeologous; and extensive structural differences involving all three genomes are present. This clearly indi-

cated that despite regular bivalent formation in the tetraploid species, they are not amphidiploids because the donors of the A and B genomes must have been closely related. The conflict between bivalency and homoeology can be resolved by assuming the presence of a diploidizing mutation, effective only in the homozygous condition.

Chromosome addition lines—New chromosome addition lines are being produced to facilitate the transfer of useful genes from diploid species to hexaploid cultivated oats. With the aid of embryo culture, hybrids were produced between Saia, a rust-resistant strain of diploid *A. strigosa* Schreb., and Rodney O, a genetic stock of *A. sativa* L.

Monosomics—The isolation of four new monosomic lines raised the total number of monosomics to 18 out of a possible 21.

Medicago

Diploid selection—Selection at the diploid level in alfalfa, followed by chromosome doubling and crossing at the tetraploid level, is being studied to exploit the vast resources of the diploid species. In 1966 the chromosome number of the exceptionally vigorous Russian diploid line 542 of *M. falcata* L. was doubled with colchicine, and the resulting tetraploids were sib-crossed in the greenhouse. Seedlings were selected for vigor and were checked cytologically. The tetraploids were highly self sterile, but they set seed readily when crossed with unrelated tetraploids.

A field nursery was established in September 1967 to compare the original diploid *M. falcata* 542 with F_1 and F_2 plants from the doubled diploids and with F_1 plants crossed with unrelated commercial alfalfa varieties. They will be evaluated for vigor, leafiness, winterhardiness, and fertility to determine their possible use in a breeding program.

Alfalfa trisomics—Crosses were made between known trisomic diploid lines and diploid plants carrying specific, easily identified genetic characters to establish linkage groups. Preliminary results have been obtained from four characters: black calyx spots, yellow cotyledon, yellow growing point, and black vs. white seed coat.

Mutation Cytogenetics

A diethyl sulfate induced curled-leaf mutation, *Cu,* was obtained in *Chenopodium rubrum* L. The mutated gene caused marked enlargement of all parenchymatous cells in the stem internodes, distorted tissue development, and often drastically altered orientation to such an extent that internodes rapidly doubled their normal size, each leaf was curled clockwise, and plants were shorter, had fewer leaves, and were delayed in maturity. The mutation did not alter the frequency of cell division; the same number of components of the various tissues were present at maturity in the internodes of the curled-leaf mutant and the wild type. There was no change in the sequence of tissue development in the cell types comprising these tissues or in their maturation.

The *Cu* mutation is incompletely dominant and monogenic. X-ray treatment induced a high frequency (21.5%) of back mutation to the wild type. Distorted segregation in selfed progenies suggests the presence of either chromosome irregularities or an extra-nuclear factor.

EXPERIMENTAL FARM, FORT WILLIAM

Crop Management

Management systems for trefoil—Pure stands of Viking trefoil, although subject to winter killing, yielded significantly more fodder than either Leo or Empire, irrespective of the stage of growth at which the crop was harvested. Leo yielded substantially more than Empire. For maximum yields a mixture with timothy is

better than the legume alone. For successful establishment a low seeding rate of the grass (2 lb/acre) must be used. The crop should be cut when the legume reaches the 25% bloom stage.

Management systems for Vernal and Du Puits alfalfa—In pure stands, alfalfa was more productive when cut at the 25% bloom than at the late bud stage. Vernal exceeded Du Puits in total yield. In mixtures with grass, Vernal performed equally well with brome or timothy; the greatest production was attained when cut at the legume early bloom stage. When harvested at the late bud stage of the legume, digestible dry matter was highest for alfalfa in mixture with brome followed by pure alfalfa. Orchardgrass with alfalfa, harvested at the same period, has a higher digestible dry matter than the same legume in mixture with timothy. Digestible dry matter declines rapidly beyond the legume early bloom stage for all species under test.

Alfalfa and trefoil growth curves—Under full plant stands the trefoils, particularly Empire, surpassed alfalfa in plant development from the end of June until late July. Viking trefoil produced more plant material than Empire, or Du Puits and Vernal alfalfa in the early season and exceeded alfalfa in total production. Du Puits alfalfa commenced growth earlier than Vernal, but by early July Vernal provided more plant material. Peak periods of production for alfalfa and trefoil vary with the season. Generally, alfalfa reached its peak by the third week of July, whereas trefoil peaked 1 to 2 weeks later.

Companion crop management—Because frequently it is impossible to secure forage returns in the year of establishment at Fort William, it is advantageous to seed down with a companion crop of oats at less than the normal seeding rate. Highest cash returns were secured when the oat companion crop was managed for grain and straw. In a comparison of seeding rates and row spacings, highest grain returns were obtained from the medium seeding rate of 2.5 bu/acre at the narrow row spacing of 7 inches. Companion crops reduced hay yield in the first harvest year, particularly under a high seeding rate of 3.5 bu/acre at 7-inch row spacings, and when the oat crop was managed as green feed.

Date of seeding barley for maximum returns—In a comparison of York, Herta, and Keystone barley, the average yield for all varieties was 38.5% higher in favor of early (April 26) vs. late (May 18) planting. Keystone outyielded Herta and York at the first three seeding dates. Varietal yield differences disappeared at the May 18 planting.

Chemical fertilizer rates for potatoes—Chemical fertilizer, 8-16-8, applied at 400 to 2,400 lb/acre in 400-lb increments at planting time, raised potato yields linearly from 82.6 cwt/acre for the check plot, to 484.7 cwt/acre at the 2,400-lb rate. In terms of marketable tubers produced, cost of fertilizer, and market value of the crop, the most economical rate was 1,200 lb/acre. The percentage of oversized tubers increased with the rate of fertilizer application. All nonfertilized plots produced an average of 11.5% culls. Tuber specific gravity tended to decline as rate of application increased above the 400-lb level.

EXPERIMENTAL FARM, KAPUSKASING

Soil Science

Crop Fertilization

Nitrogen, phosphorus, and potassium requirements of grasses—Timothy, brome-, orchard-, and reed canary-grass on Kapuskasing clay responded to annual N applications of from 0 to 240 lb/acre in the order reed canarygrass > orchardgrass > bromegrass > timothy. Only bromegrass responded to 22 lb/acre of applied P. A significant positive NP interaction on or-

chardgrass, bromegrass, and timothy indicated that P needs to be applied to make efficient use of extra N. There was no significant plant growth response from applications of K.

Nitrogen, phosphorus, and potassium requirements of a trefoil–timothy mixture—Results to date show a significant response to 120 lb N/acre applied in a split application. Increased yields were from the timothy component of the mixture at the expense of the trefoil component. As N was increased from 0 to 120 lb/acre, trefoil decreased from 80 to 20% of the sward; timothy increased in direct proportion to the decrease in the trefoil component. There were no significant responses from P or K.

Nitrogen fertilization of grass species—Repeated observations have shown the need to apply N on grasses each year and at the start of each growth cycle. Maximum yields under a two-cut system, were obtained from split applications of 300 lb N/acre for reed canarygrass and orchardgrass, and 240 lb/acre for timothy and bromegrass. In brome-, orchard-, and reed canary-grass, N had a greater effect on the aftermath yields than on the first harvest. The reverse was true for timothy. All species showed residual effects on aftermath from N applied on the first harvest.

Nitrogen fertilization and management of creeping red fescue—Red fescue responded well to split applications of N up to 90 lb/acre on the first cut and 60 lb for aftermath growth. In a study of cutting dates, yields reached a plateau about July 26. Best aftermath production was secured after 7 weeks of regrowth.

Nitrogen, phosphorus, and potassium requirements of cereals—In experiments to determine the NPK requirements of oats, barley, and wheat, both straw and grain yields were increased by adding N up to 150 lb/acre but not P or K. Barley and wheat showed increased weight per thousand kernels up to 150 lb of N, whereas oats responded only to 75 lb. Seventy-five lb of K increased the kernel weight of oats and barley, but had no effect on wheat. Maturity of the three species was hastened by both N and P.

Polyethylene mulch for vegetables—Sweet corn, cucumbers, and tomatoes seldom reach maturity and marketable size in northern Ontario. A clear plastic mulch gave excellent results with these vegetables. Maturity of sweet corn was advanced by 18 days. The yields of cucumbers increased by 350% and that of ripe tomatoes by 47%. Results suggest that marketable sweet corn and cucumbers may be produced with the aid of a clear plastic mulch.

Drainage

Tile drainage (16)—Permeability of the soil in the clay belt of northern Ontario and northwestern Quebec is very poor. Tile drains placed 18 m apart in trenches 45 cm wide and covered with gravel and muck did not improve soil drainage. Long-term results showed that soil moisture decreases with depth, and that variations in surface moisture are closely related to rainfall. Moisture levels in the plant root zone are more dependent on rainfall than on the water table.

Animal Science

Beef Cattle

Etiology of nutritional muscular dystrophy—Nutritional muscular dystrophy (NMD) is endemic in beef calves in northern Ontario. The selenium and vitamin E contents of forages grown in the area were closely related to the incidence of the disorder. The results of a cooperative study are reported by the Animal Research Institute.

Winter - housing requirements and planes of nutrition for an intensive cow-calf operation—Three winter housing conditions are being compared: standard dairy cattle housing, a pole barn, and an outside area with windbreaks. Three planes of nutrition are being used: full feed, 75% of full feed, and 50% of full feed. Planes of nutrition are being further subdivided into hay and silage.

Cows wintered outside have not suffered any ill effects. Those on 50% of full feed lost weight, but gave birth to vigorous and healthy calves. Further details of this cooperative study are reported by the Animal Research Institute.

EXPERIMENTAL FARM, SMITHFIELD

Crop Management

Vegetable Crops

Populations of canning tomatoes—Commercial canning tomato populations in the region bordering on Lake Ontario vary from about 4,000 to 7,000 transplants/acre. Results indicated that, with efficient use of irrigation, profitable yield increases can be obtained from populations as high as 10,000 to 11,800 plants/acre. Maximum single harvest yields ranging from 21.3 to 37.2 tons/acre, depending upon variety, were obtained at 15,000 plants/acre. Even under irrigation, average fruit size decreased approximately 0.5 oz as the population increased from 5,000 to 20,000 plants/acre, with the greatest effect during the early part of the harvest season.

Canning crop rotation (34)—Short-term rotations are needed to make efficient use of the soils that are suitable for canning crops. In a study of six rotations satisfactory yields were obtained from one crop of tomatoes, one of corn, and either one or two crops of peas in a 4-year period. Two green-manure crops, Sudan grass and fall rye, were planted after removal of each pea crop and either 12 tons of manure or 3 tons of straw with 500 lb of 10-5-10 fertilizer were applied every 4 years. There was a general increase in soil organic matter during the period 1959–64 and a slight decrease since that time owing to drought-depressed growth of green-manure crops in 1963, 1965, and 1966. The organic matter change from 1959 to 1964 was +0.51% and from 1964 to 1966, −0.27%.

Fruit Crops

Control of biennial bearing of Kinkead Red Spy—In trials conducted in 1966 and 1967 in an attempt to control the alternate bearing habit of 20-year-old Kinkead Red Spy apple trees, supplemental N in the form of 4 lb/tree of NH_4NO_3 was more effective in promoting return bloom than two early summer sprays of urea. Both treatments were applied during the on and off years.

Thinning with carbaryl at petal fall plus 10 ppm naphthaleneacetic acid (NAA) 10 days later, or carbaryl at petal fall plus carbaryl 10 days later was no more effective in promoting return bloom than supplemental N. Thinning during the on year combined with supplemental NH_4NO_3 was the most effective treatment in producing a crop during the off year. Although the carbaryl sprays did not remove as many fruitlets as the carbaryl plus NAA when applied during the on year, the return bloom and total yield over the 2 years were equal.

The thinning plus supplemental NH_4NO_3 doubled the yield of fruit acceptable for processing over the 2-year period. The amounts of bitter pit from the treatments were the same in 1967 even though the trees that had been fertilized with N contained more fruit with the disorder.

Effect of Alar on Red Melba—Alar, applied to Red Melba apple trees at 0.5 and 1 lb/100 gal 40 and 50 days before harvest, gave excellent drop control especially at the 1-lb rate. At that rate pressure test readings on the fruit were 3.5 to 4 lb higher and the fruit had a higher starch content than the controls. Fruit from trees treated at the higher rate and harvested on August 31, stored at 32 F until September 7, and left at room temperature for 1 week had significantly less internal breakdown and storage rot than the controls, and the fruit was firmer. With Alar, a once over pick of Red Melba is an important possibility for grower consideration.

Effects of Alar and MH30 on productivity and runner development of Redcoat strawberries — Alar and MH30 were applied at three concentrations in the year of planting to Redcoat strawberries at 12-inch spacing in the row, and were compared with hand-thinned plants (four runners per plant retained), and a control matted row planted at 18-inch spacing. Although yields from hand-thinned rows tended to be highest and MH30 treatments tended to reduce yields, the differences between most Alar-treated plots and the controls were not significant. Similarly, Alar-treated plots had higher plant populations and MH30 plots had lower plant populations than matted-row control plots, but again the differences were generally not significant.

Alar at 2,500 ppm applied at 2- and 3-week intervals, beginning with runner appearance, to Redcoat grown under plastic mulch in triple rows at 12 × 12 inch spacing failed to control runner formation. Similar applications of MH30 at 3,000 ppm controlled runners and eliminated the necessity of hand clipping. Although yield differences between treatments were not significant, an increase of 3,000 to 4,000 lb/acre was obtained from Alar, MH30, and hand clipping.

Thinning apples in eastern Ontario— Response of apple trees to NAA and other chemical thinning agents varies between seasons and between orchards during a given season. This suggests that fruits reach a specific developmental stage during which they are very sensitive to NAA, and that erratic responses are the result of the lack of an accurate index of this sensitive stage.

Indices currently used for timing thinning sprays include elapsed time after full bloom or petal fall and, to a lesser extent, mean fruit diameter (a single mean for all varieties). In 1966 and 1967 elapsed time from full bloom was the least consistent index for timing NAA sprays for maximum response. The number of days after petal fall was accurate for McIntosh but not for other varieties. Mean fruit diameter appeared to be a good index for McIntosh and Spy, but not for Delicious and Spartan.

Statistically equivalent thinning in 1966 resulted from a wide range of treatment times for three of the four varieties studied. During 1967, however, timing was critical for all varieties; significant thinning of Delicious fruits, for example, resulted only from a spray applied when fruits averaged 7.8 mm diameter. This suggested that desirable thinning would be expected annually if the indices used were the mean diameter values that resulted in maximum thinning during seasons when timing was critical. The results also indicate that different mean diameters will be required for different varieties.

Physiology

Effect of naphthaleneacetic acid on parthenocarpic McIntosh apples—The site of thinning action of NAA is thought to be the seeds. If true, NAA should not induce abscission of parthenocarpic apples. NAA failed to thin parthenocarpic McIntosh, produced by treating emasculated blossoms with gibberellic acid (GA), during 1966 or 1967. In fact 4% more parthenocarpic apples remained on NAA-treated than on parthenocarpic control trees, but the degree of abscission did not differ significantly between these two treatments during either season. Excessive abscission (86%) occurred on nontreated trees in 1966, masking thinning effects of NAA on seeded fruits. Other nontreated trees in the same orchard lost only 69% of the crop through natural drop. Thinning results of NAA on seeded fruits were pronounced in 1967.

These findings tend to support the hypothesis that the site of action of NAA is within the apple seeds. However, the possible tendency of NAA plus GA to reduce abscission of parthenocarpic fruits suggests that the two growth substances may interact in controlling fruit abscission.

Rapid dehydration of plant tissues with tetrahydrofuran—Tetrahydrofuran (THF), used to dehydrate animal tissues, may be used to advantage in preparing apple and peach seeds for paraffin sectioning by the

following method. Fix developing seeds, pricked with a sharp needle (apple) or shaved slightly with a razor blade (peach) to facilitate penetration, in formaldehyde – acetic acid – alcohol and transfer them directly to absolute THF in glass containers (THF dissolves certain types of plastic vials). Replace the solvent three or four times at intervals of 1 to 1½ hr. Immediately after the last change add a small amount of melted paraffin to the THF and place the containers in an oven at 60 C. Conduct subsequent paraffin infiltration, embedding, blocking, and sectioning steps according to established methods. THF dehydration results in slides essentially equal to those from tertiary butyl alcohol dehydration and saves considerable time.

Effects of rootstock and soil type on cumulative yields of McIntosh and Spy—McIntosh and Spy apples were grown for 20 years on six different rootstocks, appropriately replicated between two soil types. On Bondhead loam, cumulative yields of McIntosh were highest for trees on *Malus robusta* 5 roots, but yields were not significantly higher than those from trees on M II, M I, or M XII. Trees on the latter two rootstocks produced approximately 1,300 bu/acre (cumulative) less than the McIntosh–Robusta combination. When grown on Antonovka and M VII roots, McIntosh trees were significantly ($P = 0.05$) less productive than the highest yielding combination. Spy trees on M II roots were significantly more productive than any other combination except Spy on M VII. Productivity of this variety on M VII, M I, and *M. robusta* 5 rootstocks did not differ significantly, but when grown on M XII Spy yields were significantly reduced.

On Brighton gravel, both McIntosh and Spy trees were less productive than trees growing on loam irrespective of rootstock. Although McIntosh yields did not differ significantly between combinations, this variety tended to be most productive when grown on M I and least on *M. robusta* 5. Cropping of Spy on Brighton gravel did not differ significantly between rootstocks with the exception of the low yielding Spy–Antonovka combination. It appeared to be slightly more productive when grown on M I than on M II, M VII, or *M. robusta* 5 roots.

Considering the winterhardiness of rootstocks and these performance data, it was concluded that McIntosh and Spy should be grown on *M. robusta* 5 in this area; adequate moisture and nutritional levels must be maintained, particularly on poorer soils.

Food Processing

Potato Chip and French Fry Tests

In tests of potatoes from Ontario Regional Potato Trials, two seedlings, F5850 and B5141-6, scored as high or higher than any of the standard varieties from both 53 F and 40 F storage. At Smithfield, Simcoe, and Preston, F5850 showed a tissue necrosis considered to be heat necrosis in 10 to 20% of the tubers.

In a test of varieties from three locations processed at four periods from January to June, F5850, Kennebec, and B5141-6 were the only tubers under test to produce satisfactory chips and French fries throughout the whole period.

Vegetable Breeding

Tomato Variety Development

Work is continuing on the development of tomato varieties suited to this area. Determinate (*sp*) lines containing the high crimson color have been selected with improved fruit quality, and color as intense as the original indeterminate lines. In addition, high crimson determinate lines have been developed that are as early as Fireball.

New variety—Trent was released in 1967, after 2 years of semicommercial trials in the area, to fill a need for a

variety suited to local conditions. It is a midseason variety, which ripens a few days later than Rideau. The vine is determinate and gives adequate cover to the fruit. The fruits are slightly spherical and have thick walls, good structure, very little cracking, and good resistance to blossom-end rot and drought. The color is moderate to good in a 6 to 7 oz fruit. As a canned product, Trent has good color and good retention of wholeness. Over the past 5 years yields have averaged 3 to 4 tons/acre higher than those of commercial varieties.

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INTRODUCTION

Research at this station is concentrated on control of pests, mainly of horticultural crops in the province of Ontario by chemical and biological means.

A new project on the chemical control of nematodes was started, the first of its kind in Canada.

Surveys of nematode damage on a wide range of crops and of fungal and bacterial diseases of vegetable crops were completed in 1967. The Ontario Nematode Advisory and Diagnostic Service, a joint federal–provincial undertaking located here, was extensively supported by Ontario growers and completed its busiest year to date.

With the completion of the new laboratory–greenhouse complex at Vineland Station in 1967, the laboratories at St. Catharines and Simcoe were closed.

W. B. Mountain
Director

VERTEBRATE PESTS

Bird Damage to Cherries and Grapes

Dr. R. G. B. Brown, Canadian Wildlife Service, was based at the Station from June to October, while he worked on problems concerning bird damage to fruit. The aim of this research was to collect background information on the birds' feeding behavior to form the basis of more efficient protection systems. The fruits mainly damaged are sweet cherries (especially the early ripening varieties) and grapes (especially the French hybrids and New York Muscat). The species doing most of the damage are robins and starlings, and to a lesser extent grackles, Baltimore orioles, and house sparrows. Dr. Brown concentrated on local variations in the degree of damage, and is attempting to relate these to variations in such factors as sugar and pH values, density of foliage, distance from woodlot type of cover, and weather. He also tested protective devices. Exploders and

suspended model "hawks" were ineffective; protective netting was effective, but it may prove to be too expensive for practical purposes. Dr. Brown believes that the best long-term solution is to establish the chain of factors that controls fruit eating in birds. and then find a way of interfering with it at its weakest point.

CONTROL OF PESTS

Chemical Control of Fruit Pests

Insecticide–acaricide trials—The Pesticide Testing Group and others tested 60 materials (nine of them for the first time) in the greenhouse and orchards for the control of several species of insects, mites, and diseases.

In a seasonal control program of six cover sprays on apples, experimental compound N-4543 had a longer residual effect and gave better control of the codling moth than eight other materials, including the currently used Imidan and azinphos-methyl. Unlike the last two materials, the six sprays of N-4543 also controlled the European red mite, though one spray in a separate experiment was not effective.

Of 26 materials tested against the apple aphid, the most effective were menazon, phosalone, formothion, vamidothion, and Banol. They gave as good control as the currently used diazinon, dimethoate, and endosulfan.

The most promising new materials against the two-spotted spider mite in the greenhouse were Galecron, Acaralate, Milbex, fenoflurazole, and Azodrin. The last two caused some foliage injury which may limit their use on fruit trees.

Single sprays of carbaryl, DDT, azinphos-methyl, phosalone, Imidan, and malathion all gave almost complete control of a heavy infestation of the potato leafhopper on young apple trees.

Twelve experimental compounds and three registered insecticides were compared in seasonal spray programs in a pear orchard. Galecron, Gardona, and dimethoate gave the best control of the pear psylla, the pear rust mite, and the European red mite.

Fungicide trials—In an evaluation of fungicides for the control of brown rot of peach fruit, dichloran reduced the incidence of the disease from 20% to 0.5% and gave better control than captan, a combination of captan and dichloran at half rates, sulfur, tetrachloroisophthalonitrile, and a water check.

Tests of commercially available fungicides for the control of scab and powdery mildew on apple confirmed the high degree of activity of captan, dodine, and mancozeb towards scab and their ineffectiveness against powdery mildew. Sulfur and binapacryl showed high activity towards mildew, but failed to control scab. Dinocap gave a slight control of mildew, but was markedly inferior to both sulfur and binapacryl. Folpet showed the broadest activity, giving good control of scab and a slight but significant control of powdery mildew.

DDT for codling moth control—After almost 20 years of continuous use, DDT was still effective against the codling moth in apple orchards in the Georgian Bay area. A few control failures there in 1966 were probably due to improperly timed sprays. Ten years ago a strain of the codling moth highly resistant to DDT developed in a few orchards in the Niagara Peninsula and most apple growers there and elsewhere in southern Ontario switched from DDT to parathion and later to azinphos-methyl.

Control of resistant strains of the European red mite—The rapid development of strains of the European red mite resistant to many recommended acaricides is seriously hampering the control of this major pest of fruit crops in Ontario. Genite has been withdrawn from apple recommendations because of widespread mite resistance to it in Norfolk County. There is also evidence of resistance to dicofol and tetradifon in a few apple orchards. In the Niagara region, resistance to dicofol has been confirmed in a few peach orchards

and numerous reports of control failures in 1967 indicate that resistance to both dicofol and tetradifon may be prevalent. Mites in one peach orchard were resistant to the organophosphorus compounds parathion, ethion, mevinphos, and azinphosmethyl, and to the chlorinated acaricides dicofol and ovex. However, low to moderate populations of the mite were controlled by the organophosphorus compound demeton and the dinitro compound binapacryl. The following unregistered experimental acaricides also controlled these resistant mites: Plictran (Dowco 213), Galecron (C8514), NC5016, Chloropropylate, and Azodrin. Azodrin caused extensive leaf injury to peach and cherry trees but not to McIntosh apple trees.

Binapacryl, oxythioquinox, and dinocap applied in eight sprays at 10-day intervals to control powdery mildew on McIntosh apple also maintained the European red mite at very low levels although before treatment the mite populations in the test orchard were relatively small.

Acaricides effective against winter eggs of the European red mite—Animert, a sulfide acaricide, and the emulsifiable formation of tetradifon, its sulfone analogue, killed appreciable numbers of winter eggs and young of the European red mite. The wettable powder formulations of tetradifon and of dicofol were not effective against the winter eggs. Therefore, Animert and tetradifon emulsifiable concentrate should be more effective in prebloom sprays during those seasons when the hatching of the winter eggs has been delayed by cool wet weather as in 1967.

Effect of fine atomization on coverage and control—Pear trees were sprayed with an experimental air-shear sprayer that produced droplets of 70 to 90 μ; it gave good coverage of leaves and fruit at an application of only 26 gal/acre. Dicofol was applied at three rates: the recommended dilute rate of 5 lb/acre, and at 3 lb and 1 lb. Rust mite populations were largest at the 1-lb rate, but all rates gave economic control.

A survey of orchard spraying in Ontario—Fifteen manufacturers provided sprayers for orchard use. Methods of application included high volume dilute, low volume low concentrate, very low volume high concentrate, and ultralow volume with straight technical pesticide. These and the great variation in tree size and shape and the wide selection of pesticides compounded the difficulty of making simple recommendations. In future tests, sprayers must be more carefully cleaned and adjusted, and sprays timed more accurately. The survey emphasized the need for more information on amount of pesticide needed, the most effective form of deposit for each pest, how to use existing machines efficiently, and the best timing of applications.

PESTICIDE RESIDUES

Pesticide Residues in Crops and Soil

Experiments on DDT residues in the foliage and fruit of grapes from sprays for insect control have brought out several points of interest. At harvest, after a maximum of four sprays, the highest DDT concentration found in the fruit was 1 ppm. The concentration depended on the variety of grapes and to a certain extent on the number of sprays. Ninety five percent or more of the residual DDT in the fruit was in the skins.

Spray drift was of special interest. Samples collected from the control plot 3 hr after the adjoining plot was sprayed were contaminated with slight amounts of DDT, even though the sprays were applied only when the wind was away from the control plot.

A strong possibility of DDT translocation from the soil to leaves and fruit was suggested by the finding of very low levels of DDT residues (less than 0.1 ppm) in the samples of leaves and prebloom clusters. These samples were collected early in the season from both sprayed and control plots before any DDT treatments in the vicinity. The soil in both plots contained about 4 ppm DDT from treatments in previous years.

Development of Simplified Analytical Methods

A method of determining carbaryl residues, based on colorimetry, was developed. Unlike other pesticide-residue methods, it does not require any sophisticated instruments. This method was originally developed for extension specialists to analyze leaves in the field, but it should also be useful for others working on pest-control problems.

A complete analysis, consisting of four procedures, takes less than 2 min per sample when a large number of samples are analyzed. The application of this technique for other insecticides and fungicides is currently being studied.

ECOLOGY OF INSECTS AND MITES

Factors Affecting the Population Dynamics of the European Red Mite in Peach Orchards

In 1966 a disease of the European red mite, apparently associated with a virus, appeared in some heavily infested peach orchards and virtually eliminated the populations before many winter eggs were laid. The initial mite infestations in the spring of 1967 were consequently small, and buildup was further delayed by cold wet weather. On the much reduced populations of this year the disease did not appear until late September, after a profuse deposit of winter eggs.

The disease proved to be infectious in the laboratory, having undergone four serial passages by the end of the year. Healthy mites became infected when they were put on leaves on which diseased mites had been reared, or on which triturated diseased mites had been smeared. It was also transmitted when a suspension of triturated infected mites was applied to the mouths of healthy mites, but not when applied to the dorsum. Any of the active stages may become infected. Healthy females were also infected when they were inseminated by infected males. Many of the progeny of these matings were also infected, but transovarian transmission has not been proved.

Behavior and Ecology of the Oriental Fruit Moth

Factors affecting oviposition — Field-collected oriental fruit moths laid very variable numbers of eggs when caged under similar conditions in an open insectary. This variation made attempts to correlate oviposition with weather unsatisfactory. Egg production tended to increase with successive generations during the summer, apparently independent of temperature. In 1966 there was no difference between the average number of eggs laid by single females caged with up to four males, and by females caged in groups of five with males. But in 1967, females caged in groups of five laid twice as many eggs per female as those caged singly. An average of 38% of the moths laid no eggs, although 71% of these had been inseminated at least once. Caging five female moths together with males did not significantly increase mating.

Preliminary experiments seem to indicate that moths held for 8 days at a temperature just below the threshold for oviposition laid fewer eggs than normal after the temperature was brought to optimum, while those held for 8 days at a temperature low enough to inhibit activity laid about a normal number of eggs when brought to optimum temperature. There was some evidence for egg resorption at the higher temperature.

Caged moths in the insectary usually drank water only during the mating and egg-laying period of the day, from about 4 hr before to 1 hr after sunset. Lack of drinking water shortened the life of the moths by about one-half; it did not significantly reduce their total egg production because about 90% of the eggs were laid during the first week, before appreciable mortality occurred from lack of water.

An artificial diet for the oriental fruit moth—An artificial diet developed for the codling moth in Washington State and British Columbia (M. D. Proverbs) was

modified and used at Vineland to rear the oriental fruit moth. The substitution of half the white pine sawdust in the B.C. diet by fine peach-wood chips gave a moister, coarser-textured medium that was apparently more suitable for entry by the larvae. Four successive generations have been reared on the diet. At a temperature of 25 C and a relative humidity of 72% the development period of larvae on the diet was 3 to 4 days longer than on green apples. However, the pupae were larger and of a more uniform size than those produced on green apples, and females laid more eggs. Although rearing techniques have not been fully worked out, and there is still considerable variation in the number of moths produced per unit of diet, it appears to be promising as a substitute for green apples for rearing laboratory colonies of the oriental fruit moth.

Population Dynamics of the Oriental Fruit Moth

Correlation of generation size—Analysis of recent data and records at this laboratory going back about 20 years indicates little or no correlation between sizes of successive generations of the oriental fruit moth. There was a small correlation between the size of the third generation in the fall and the first generation in the following spring. The third generation is very lightly attacked by parasites. There was poor correlation between first and second, and second and third generations. No long-term population trends were evident.

Parasitism—A large increase in percentage of parasitism by *Macrocentrus ancylivorus* Rohwer occurred in 1967. Overwintered moths were more numerous than in any previous year of this study, but egg laying was delayed by cool wet weather. Parasitism of the first-generation larvae was 57% and of the second-generation larvae 71%. This is the first indication in this study that the parasite responded to population density and it appeared to effectively reduce the number of moths maturing in the second generation. Much more information is needed to determine the relationships between population size, weather, and parasitism. However, our records of the past season give some hope that the parasite may be used effectively for fruit moth control.

Grape Phylloxera

Strains of the grape phylloxera in Ontario—At least two strains of the grape phylloxera were distinguished by their ability to incite galls on the leaves of certain cultivars. The French hybrid Foch and the rootstock 3309 reacted to phylloxerae collected from wild grapes and certain other cultivars by developing necrotic spots instead of galls on the leaves that were attacked. Only phylloxerae collected from galled leaves of Foch in the field were capable of inciting galls on Foch in the field or laboratory. Phylloxerae collected from 3309 in the field produced an intermediate reaction on Foch, whereas insects from both Foch and 3309 produced galls on 3309 in the laboratory.

Trapping winged migrants of the grape phylloxera—No differences were observed in the numbers of alate phylloxerae trapped on sticky surfaces on clear, white, or variously colored backgrounds. Most alatae were taken on traps in the immediate vicinity of the foliage, though small numbers were captured on traps at a height of 15 ft and up to 160 ft from the vines. Alatae were captured throughout August and September, peak numbers occurring just after mid-September.

Ecology and behavior of motile gallicoles of the grape phylloxera—In the vineyard, first-instar crawlers dispersing from galled leaves showed a significant movement towards the tips of vertical shoots and a much less significant movement towards the tips of horizontally oriented shoots. On declining shoots, most moved toward the bases of the shoots. In the laboratory about 70% of the crawlers moved upwards when released on a paper leaf attached to a vertical rod.

In the laboratory, crawlers responded positively to a horizontal beam of light and showed a definite preference for the lighted half of a test arena. Crawlers exposed to a temperature gradient on a horizontal surface were repelled by a surface temperature between 34 and 36 C.

The ability of crawlers collected from infested vines in the field to incite galls on grape plants in the laboratory declined with successive generations during the season.

Laboratory-reared crawlers survived exposure to approximately −10 C for up to 30 min with little mortality, but all were killed by an exposure of 45 to 60 min.

PLANT DISEASES

Survey of Diseases of Fruit Crops in Ontario

Peach canker—The loss of limbs of peach trees due to peach canker, caused by *Cytospora* spp., reached serious proportions, as it did in 1966. Some infection had occurred through leaf scars during the previous autumn, but the girdling of major limbs resulted from the rapid spread of the fungus from existing cankers, during an unusually long period of cool weather in the spring. It is estimated that the peach production from existing acreage could be increased by approximately 20% if winter injury and peach canker were controlled.

Apple canker—This complex of canker diseases is of relatively minor concern to the apple industry, although it is damaging in certain orchards. Reduction in annual fruit production in Ontario from this cause was approximately 0.1%. Several fungi were associated with apple cankers, but most of the cankers appeared to be the result of poor cultural practices, particularly excessive fertilization leading to sunscald and winter injury, especially in the variety Northern Spy.

Fire blight—This disease, caused by *Erwinia amylovora* (Burr.) Winslow et al., was of light to moderate incidence on pears and accounted for an estimated 0.2% reduction in the crop. It was more serious on apple than it had been for several years, resulting in a crop loss of about 0.3%.

Apple scab—Although the growing season was favorable for an early establishment of scab, fungicide spray programs effectively controlled this disease, which was serious in only a few orchards, where late or inadequate fungicide application was implicated. Fruit losses were difficult to estimate, but were probably less than 1.0%.

A Survey of Diseases of Vegetable Crops in Eastern and Central Ontario

The first systematic survey of vegetable diseases in eastern and central Ontario was made in 1967. In eastern Ontario two diseases were observed on lettuce and single diseases on beans, carrots, and tomatoes. In central Ontario the highest number of diseases was detected on tomatoes, onions, cabbages, and cucumbers. Single diseases were observed on asparagus, beans, Brussels sprouts, and carrots. Most of these diseases were caused by fungi.

Of the fungus diseases in central Ontario, species of *Fusarium* caused the highest number of diseases followed by species of *Alternaria, Botrytis,* and *Pythium* in that order. Species of *Erysiphe, Plasmodiophora,* and *Septoria* each caused one disease. Species of *Xanthomonas* and *Pseudomonas* caused most of the bacterial diseases.

In eastern Ontario, only carrot leaf-blight, *Cercospora carotae* (Pass.) Solh., was observed to be severe. Tomato bacterial canker, *Corynebacterium michiganense* (E.F. Sm.) Jensen, was moderate, while bean root rot (*Fusarium* spp.), and damping-off (*Fusarium* spp.) and drop, *Sclerotinia sclerotiorum* (Lib.) de Bary, of lettuce were at the trace level.

In central Ontario, some of the diseases that reached severe intensity were black rot, *Xanthomonas campestris* (Pamm.) Dowson, of Brussels sprouts and cabbage, and cabbage leaf spot, *Alternaria brassicae* (Berk.) Sacc. Some diseases that reached moderate intensity were beet damping-off (*Rhizoctonia solani* Kühn, *Pythium* spp., and *Fusarium* spp.), and bacterial leaf spot (*Xanthomonas* sp.) and black rot, *Xanthomonas campestris* (Pamm.) Dowson, of cauliflower.

Diseases that reached slight intensity were cabbage yellows, *Fusarium oxysporum* Schlecht. f. *conglutinans* (Wr.) Snyd. & Hans., carrot leaf blight, *Alternaria dauci* (Kühn) Groves & Skolko, cauliflower leaf spot, *A. brassicae,* and cucumber bacterial wilt, *Erwinia tracheiphila* (E.F. Sm.) Holland. Diseases that occurred at the trace level were asparagus root rot (*Fusarium* spp., *Rhizoctonia solani, Pythium* spp.), bean damping-off (*R. solani, Fusarium* spp.), and clubroot, *Plasmodiophora brassicae* Wor., and damping-off (*Fusarium* spp.) of cabbage.

PLANT VIRUSES

Carnation Viruses

The influence of supplementary carbohydrates and nitrogen on lesion formation by carnation mottle virus was studied on several hypersensitive hosts. Detached leaves of *Chenopodium amaranticolor* Coste & Reyn. incubated in the dark at 21 C after inoculation with carnation mottle virus and supplemented with relatively high sucrose concentrations developed significantly more local lesions than those maintained in distilled water in the dark. The lesion increase was dependent on the sucrose concentration; it was not evident at 1 and 5%, but appeared at 10%. At higher concentrations the number of lesions progressively increased. More local lesions also formed in the dark on detached leaves fed with fructose, dextrose, or raffinose than in the dark in distilled water. In general, the lesions induced on the leaves maintained in the dark on these carbohydrates or on distilled water were much smaller and more delayed in appearance than those on the illuminated control leaves in distilled water. The continuously illuminated leaves were much more severely damaged by the virus infection. Leaves on seedlings of *Gomphrena globosa* L. and *C. amaranticolor* sprayed with 10% sucrose solution immediately after inoculation with mottle virus developed more visible lesions than plants maintained in the dark and sprayed with distilled water.

Supplementary nitrogen failed to increase the number of visible local lesions on inoculated detached leaves of *C. amaranticolor* kept continuously in the dark. In fact, fewer lesions appeared on the leaves than on those maintained continuously in the dark in distilled water. The stimulatory effect of sucrose on visible lesion numbers in the dark was partly counteracted by the addition of NH_4NO_3 to the sucrose substrate.

Tomato Ring Spot Virus in Geranium

A virus isolated from the leaves of *Pelargonium hortorum* Bailey 'Appleblossom' with large chlorotic rings was identified as tomato ring spot virus by means of differential hosts and by immunological studies with known strains of tomato and tobacco ring spot viruses. Its transmission from this cultivar to other herbaceous plants was erratic and occurred only in cucumber. Ring spot symptoms were produced in geranium Nittany Lion seedlings by inoculation with sap from infected cucumbers. The virus was recovered from all but one of the inoculated seedlings. This is the first report of the occurrence of tomato ring spot virus in geraniums in Canada.

A New Virus Disease of Cyclamen in Ontario

Conspicuous chlorotic leaf spotting, flower distortion, delayed blooming, and stunting are characteristic of a hitherto unreported disease of cyclamen in Canada. A virus has been associated consistently with plants with these symptoms. Based on its symptoms on a limited number of selected hosts and its physical properties, the virus has been provisionally identified as a strain of cucumber mosaic virus, possibly similar to one recently reported in cyclamen in the Netherlands.

Grapevine Viruses

Grapevine viruses in Ontario—The grape virus indexing program continued

and yielded six rootstocks and 15 cultivars free from fanleaf, yellow mosaic, vein banding, and yellow vein viruses. Indexing of this material to detect the possible presence of leaf roll and corky bark is in progress.

An undescribed disease of the cultivar Brighton has been investigated. Chlorotic spots appear on the leaves, sometimes followed by apical shoot necrosis. Further growth from the axillary buds is generally symptomless. Infected plants are stunted and their leaves abscise early. Cuttings from apparently healthy Brighton grafted with buds from diseased grapes developed similar symptoms after 12 to 18 months. Transmission occurred in 8 of the 10 plants grafted. Mechanical inoculations with sap from infected grapes to herbaceous hosts were unsuccessful. Present evidence suggests the possibility of a virus association with this disease, but further work is needed to confirm this fact.

A sap-transmissible virus associated with diseases of peach and grape—Mechanical inoculation to herbaceous hosts showed that peach rosette mosaic virus was present in almost all Concord grapes tested. The virus was also transmitted from infected grapes to the virus-free varieties Concord, Vital, and rupestris St. George by chip bud or green approach grafting. Symptoms produced in the indicators Vital and St. George showed that peach rosette mosaic virus is different from any other known grapevine virus.

Virus isolates from both peach and grape were transmitted back to virus-free peaches by mechanical inoculation with infectious tobacco and petunia sap or by partly purified virus preparations. Characteristic rosette mosaic symptoms were produced. However, back inoculations to Concord grapes have failed to induce the typical symptoms although the virus was recovered from the inoculated leaves.

Myzus persicae Sulz. did not transmit the virus from infected to healthy *Chenopodium quinoa* Willd. regardless of the duration of the acquisition feeding. Attempts to transmit this virus by *Cuscuta campestris* Coste & Reyn. also failed. The virus was transmitted by seed collected from infected *C. quinoa,* but percentage of transmission was low.

Infectious preparations containing polyhedral particles approximately 28 mμ in diameter were obtained by grinding the leaves in phosphate buffer with DIECA (sodium diethyldithiocarbamate) and 2-mercaptoethanol. After freezing overnight, the thawed sap was dialyzed against 20% $(NH_4)_2SO_4$ and subjected to differential centrifugation. Other methods of purification drastically reduced infectivity.

A serum against peach rosette mosaic virus (peach isolate) was prepared. Absorbed antiserum had a titer of 1/64. Serological tests with several isolates from both peach and grape showed that they were identical. Further tests confirmed that peach rosette mosaic virus is not related serologically to the grape fanleaf virus group nor to several of the soil-borne ring spot viruses.

Pome Fruit Viruses

Orchard surveys—At or just before harvest in 1966 and 1967 surveys of apple orchards were concerned with conditions of a possible virus nature that cause deformity and russeting of fruits, extreme reduction in yield, tree decline, or other severe manifestation of disease. In 1966 no important virus disease appeared to be associated with these abnormalities in any of eight apple-growing districts. In 1967, of 2,210 trees in the Niagara Peninsula two had pronounced mosaic symptoms on the leaves, but no fruit deformity or yield reduction attributable to a virus was observed. The stem-pitting virus was responsible for advanced decline of 30 trees in a 20-year-old orchard at Bowmanville, Ont. The affected trees were Virginia Crab that were top-worked at 7-8 years of age with Northern Spy scions. Very severe pitting was seen on the trunks and main branches up to the graft unions. Other Virginia Crab trees top-worked with La Salle were vigorous and free from pitting symptoms.

Color break in Northern Spy—Studies are continuing into the cause of color break in leaves and fruits of several Northern Spy trees in southwestern Ontario. The leaf symptoms are characteristic of sectored chimeras, whereas the vertical green stripe symptom in the fruit has not been seen in other crops. Seedlings from striped fruits did not show leaf

symptoms during the first year of growth. McIntosh seedlings grafted with Northern Spy buds failed to show color break during the first year. Mechanical inoculations from the Spy seedlings to herbaceous plants failed to detect a virus.

Viruses isolated from apple varieties—Mechanical transmission tests on seeds and on leaves of seedlings and forced shoots from apple trees located in experimental plots have resulted in the isolation of three apparently distinct viruses. One has been identified as tobacco mosaic virus. The other viruses remain to be identified. One is known to induce symptoms in *C. amaranticolor* and *C. quinoa* Willd. and in *Gomphrena globosa* L., *Nicotiana tabacum* L., *Petunia hybrida* Vil., and *Phaseolus vulgaris* L. The other virus has infected only the *Chenopodium* species. The reported seed transmission of tobacco mosaic virus has been confirmed. At least one and possibly both of the other viruses are seed transmissible, but the percentage of transmission is thought to be low. Studies are in progress to characterize these viruses.

Certified apple stock program—In cooperation with the Horticultural Research Institute of Ontario, 25 virus-tested apple varieties and 5 virus-tested understocks of the Malling and Malling Merton series have been established. The full range of virus indicator varieties has also been established and provision has been made for a planting of dwarf apple trees to be used in indexing for viruses responsible for fruit damage.

Stone Fruit Viruses

Tomato bushy stunt virus (TBSV) has been repeatedly isolated from seeds, petals, leaves, and pollen of sweet cherry trees with vein necrosis that caused a twisting and distortion of leaves, short-stemmed fruits with sunken circular spots, rosetting due to very reduced shoot growth, and brittle wood. Attempts to isolate this virus from seeds, leaves, and petals of 40 symptomless trees adjacent to the diseased ones have been unsuccessful.

Serological Studies

Characteristics of the immune response in rabbits—Studies have continued on the influence of dosage, route, and number of injections on the type of immune response. Over a period of 2 months single intravenous (IV) injections yielded sera of lower average cross-reactivity than single intramuscular (IM) injections with or without adjuvant. The last procedure appeared to induce the highest cross-reactivity. Five IV injections given at weekly intervals induced sera with the lowest average cross-reactivities. Multiple IM injections with or without adjuvant induced lower average cross-reactivities than comparable single injection procedures did. Again, IM injections without adjuvant induced the highest average cross-reactivity. As in former studies, cross-reactivity decreased considerably before increasing to maximum values, which were reached several months later. Generally, the period of minimum cross-reactivity slightly preceded or was coincident with the period of maximum homologous titer. Multiple injections increased the homologous and heterologous titers, but did not change the characteristics of the cross-reactivity curves other than to decrease the average values. These results led to the preliminary conclusion that early bleedings are not suitable for determining virus relationships for the following reasons: (i) significant differences in cross-reactivity may exist between weekly bleedings; (ii) during this early period the level of cross-reactivity is most strongly influenced by the immunization procedure; (iii) minimum cross-reactivities occur during this period.

Immunization technique—High-quality antisera free of antibodies to host antigens have been produced by using virus-antibody precipitates excised from agar plates after completion of double-diffusion tests. With this technique the precipitates as well as the agar matrix are injected intramuscularly into rabbits. Initial studies on the technique indicated that free virus and host antigens apparently are 'bound' to agar because 1 to 2 weeks of washing did not remove the antigens from small volumes of dilute agar. As contamination of immune precipitates due to 'binding' of free antigens would limit the usefulness of the technique, the problem was investigated. Further, it was queried if agar

possesses adjuvant characteristics and if so what concentration is optimum.

Washing tests showed that restricted diffusion and not 'binding' was responsible for the apparent retention of free virus by agar. Electrophoresis was found to be a quick method of removing free antigens from the agar matrix surrounding immune precipitates. The influence of agar concentration on immunogenicity was assessed by intramuscular injections with virus in either saline or liquid 2, 4, and 8% agar and in 10 and 50% complete Freund adjuvant. The response to virus in 4% (optimum) and 8% agar was greater than in saline or 2% agar. Agar was a much less efficient vehicle than 50% adjuvant, but only slightly less so than 10% adjuvant.

Soil Transmission of Viruses

Canadian cucumber necrosis virus (CNV) is transmitted by the zoospores of a new species of *Olpidium* (*O. cucurbitacearum* Barr & Dias) (D. J. S. Barr. A new species of *Olpidium* parasitic on cucumber roots, Can. J. Bot. In press.). Infected zoospore suspensions were obtained either by discharge from infected roots or by in vitro mixing of purified CNV and virus-free zoospores. Two zoospores per milliliter of inoculum were sufficient to transmit CNV; infectivity was found to be associated with the zoospores after washing and sedimenting at 6,600 *g* for 10 min.

A suspension of virus and zoospores failed to transmit CNV when passed through a 4- to 5-μ mesh sintered-glass filter. It transmitted the virus when treated at 40 C, but not at 45 C, which corresponds to the thermal death point of the zoospores. These results are further evidence that *O. cucurbitacearum* is the vector of CNV.

The addition of CNV antiserum to suspensions of virus and zoospores did not reduce or prevent transmission even when concentrated antiserum was used. Furthermore, zoospores required a 10-min contact with the virus suspension before they became infective. These results strongly suggest that the virus is carried within the zoospore or is intimately associated with its membrane.

Transmission of CNV by its chytrid vector was specific. *O. cucurbitacearum* transmitted CNV but not tobacco necrosis virus (TNV), whereas *O. brassicae* (Wor.) Dang., the vector of TNV, failed to transmit CNV.

NEMATODES

Nematode–Fungus Interactions

Greenhouse studies showed that the root-lesion nematode, *Pratylenchus penetrans* (Cobb) Filipjev & Stekh., did not break down the resistance of tobacco Burley 49 to the black root fungus, *Thielaviopsis basicola* (Berk. & Br.) Ferr. Tobacco Burley Kelley, which is highly susceptible to black root rot, was tolerant to *P. penetrans,* whereas *Nicotiana debneyi* Domin. remained immune to *T. basicola,* but suffered severely from the nematode.

Strains of the Root-lesion Nematode

Two populations of *P. penetrans* were used in these studies; one originated from celery and strawberry roots grown in the Niagara Peninsula, and the other was isolated from rye grown in rotation with tobacco at Delhi, Ont. Both were cultured on celery in the greenhouse, the former for 9–11 years, the latter for 0.5–1 year. The Delhi strain differed significantly from the Niagara strain in reproductive potential and virulence of attack. Further tests showed that the reproductive potential of the Delhi strain was significantly higher than that of the Niagara strain on tobacco Hicks Broadleaf but not on celery Utah.

Root-lesion Nematodes in Tobacco and Rye

Studies on seasonal fluctuations in soil and root populations of the root-lesion

nematode in tobacco–rye rotation plots at Delhi, Ont., were continued. When fall and winter fallow replaced the usual rye cover crop, soil populations of the nematode were reduced by 90% and the height of the tobacco plants increased 26% in the following season.

Ecology of the Root-lesion Nematode

Influence of the soil environment on movement—The distance that *P. penetrans* moved in Fox loamy sand, Vineland silt loam, and Jeddo clay loam was inversely proportional to the bulk density of these soils when moisture tensions were optimal for movement. Optimal moisture tensions occurred when these soils began to drain freely, that is, at the inflection point of the moisture desorption curve, which lies between saturation (0 moisture tension) and field capacity (0.3 atm moisture tension). Free drainage in the three soils occurred at increasingly greater moisture tensions as the bulk density of each soil increased.

Temperature (8–30 C) did not influence the movement of *P. penetrans* in the three soils when moisture tensions were optimal for movement. However, at high moisture tensions (1 atm), the distance traveled by *P. penetrans* in Vineland silt loam and Jeddo clay loam was directly proportional to temperature. The viscosity of water is twice as great at 8 C as at 30 C. The more viscous water at the lower temperatures likely impedes the movement of the nematode, particularly when the thickness of moisture films at high tensions are nearly minimal for movement. Moisture films at 3 atm in Fox loamy sand were too thin to show the effect of viscosity.

Distribution of the root-lesion nematodes—Five species of root-lesion nematodes were found in southern Ontario when cereal and forage crops were sampled. These were *Pratylenchus neglectus* Rensch, *P. crenatus* Loof, *P. pratensis* de Man, *P. thornei* Sher & Allen, and *P. penetrans*. *P. neglectus* was widespread and occurred in both coarse- and fine-structured soils. This species is probably indigenous. *P. crenatus, P. pratensis,* and *P. thornei* were not commonly found. Our economically most important nematode, *P. penetrans,* was found mainly in the coarse-structured soils above Lake Ontario and Lake Erie, primarily in an east-west distribution. Because this nematode was found in those areas into which rootstocks had been introduced, as in the fruit-growing areas, it may have been introduced into Ontario.

Distribution of Cyst and Root-knot Nematodes in Ontario

Field crops in all southwestern Ontario counties west of Peterborough except Essex were sampled for cyst and root-knot nematodes. Cyst nematodes were found in 58 and root-knot nematodes in 46 of 289 soil samples collected. The sugar beet cyst nematode, *Heterodera schachtii* Schmidt, was present at Sarnia and Woodbridge. The oat cyst nematode, *H. avenae* Wr., was found in 24 locations, primarily in the Kitchener and Lake Scugog districts. The clover cyst nematode, *H. trifolii* Goffart, was recovered from 33 locations throughout the sampling area. The northern root-knot nematode, *Meloidogyne hapla* Chitwood, was widespread over southwestern Ontario in all types of field crops. The clover cyst nematode and root-knot nematode were occasionally found together in forage legume crops.

Grass Hosts of the Southern Root-knot Nematode

Thirty of 34 species of grasses found in Ontario sustained galling by the southern root-knot nematode, *Meloidogyne incognita* (Kofoid & White) Chitwood, in greenhouse tests. The nematode reproduced on 27 species; 16 of these had not been previously reported as hosts. Four species were apparently immune. Wheat, barley, and rye were excellent hosts of this nematode.

MANUFACTURERS OF PESTICIDES IDENTIFIED BY TRADE NAMES

Trade name	*Manufacturer*
Acaralate	Fisons (Canada) Limited
Animert	Green Cross Company
Azodrin	Shell Chemical Company
Banol	Howard Chemical Company
Chloropropylate	Fisons (Canada) Limited
Plictran (Dowco 213)	Dow Chemical Company
Galecron (C8514)	Green Cross Company
Gardona	Shell Chemical Company
Genite	General Chemicals Company
Imidan	Stauffer Chemical Company
Milbex	Green Cross Company
N-4543	Stauffer Chemical Company
NC-5016	Fisons (Canada) Limited

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[6] Omitted by error in 1966 Research Report.

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